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EXPERIENCES WITH NEW ROUNDABOUTS IN THE NETHERLANDS

Résumé

Les Pays Bas ont construit plus de 200 ronds-points depuis 1986, la plupart en agglomération. Les nouveaux ronds-points se caractérisent par leur forme parfaitement circulaire, une voie de circulation étroite et des voies d'accès également étroites (bande de roulement unique), par des routes d'accès en étoile, de faible dimensions et par la priorité accordée à la circulation engagée sur le rond-point.
Au terme de plusieurs travaux de recherches sur la sécurité, on constate que ces ronds-points offrent une bonne protection à toutes les catégories d'usagers de la route tout en ayant des capacités d'intensité de traffic de 2000 véhicules à moteur par heure.
Les cyclistes, qui bénéficient de diverses infrastructures destinées à assurer leur sécurité, ont fait l'objet d'une attention particulière.
Cette année, une deuxième étude sur la sécurité a démarré, analysant les accidents de circulation survenus sur 150 ronds-points. Elle vise à mieux appréhender les aspects de la sécurité en fonction des différentes solutions adoptées pour les cyclistes.
Si pour l'heure l'on s'intéresse davantage aux ronds-points plus importants à deux voies avec priorité pour la circulation engagée, on envisage aussi de modifier les règles de priorité encore en vigueur sur les anciens ronds-points (avec priorité pour la circulation engagée sur le rond-point).

Abstract

Since 1986, over 200 roundabouts have been built in The Netherlands, most of them in built up area. The new roundabouts are characterised by pure circular design, narrow carriageway ans approach roads (one lan), radially oriented approach roads, small dimensions and right of way for traffic on the roundabout (off-side priority).
The results of several research projects show good safety levels for all kinds of traffic users and capacities of more then 2000 motorvehicles per hour.
Special attention is given to the various solutions for cyclists and their safety. This year started a second safetystudy, using the accident records of about 150 roundabouts, to get more insight in the safety related to the various options. There is now a growing interest in larger roundabouts with two-lane carriageways and off-side priority, and in changing the right of way on older roundabouts from near-side to off-side priority.

1. INTRODUCTION

Until about 1985, no new roundabouts were built in the Netherlands, since they were not felt to provide an effective solution to traffic flow problems. Existing roundabouts, e.g. on highways, were replaced by other forms of intersection solutions or by traffic lights. The reason why experiences with roundabouts were so negative in the Netherlands was largely due to our rules on priority, which meant that even on roundabouts, traffic had to give way to vehicles coming from the right. The positive results gained in England using the 'offside priority' rule introduced on roundabouts in 1966 did little to influence road planners in the Netherlands. This only happened much later, when in about 1984, following successful trials in Quimper, the French also began building roundabouts giving priority to traffic on the roundabout itself. About a year later, the Dutch also began building new roundabouts, beginning with just one or two in the first few years, followed by an increasing number in subsequent years. It is now a popular solution for intersections, and an estimated 300 or so new roundabouts have already been built. Until quite recently, these roundabouts had a very specific shape: i.e. a relatively small circus with a single traffic lane and narrow, radial entry lanes. This type of roundabout was found to be highly satisfactory in terms of road safety, but the often large number of cyclists using them (a typically Dutch problem) have now made it necessary to consider a more suitable solution to accommodate these road-users. Over the past few years, the SWOV Institute for Road Safety has carried out various surveys on the capacity and safety of these new roundabouts. The results of these surveys and a number of recent developments in the Netherlands will be covered by this paper.

2. DESIGN OF THE NEW ROUNDABOUTS

The new roundabouts in the Netherlands are generally small and perfectly circular; external diameters usually measure between 25 to 35 metres, although they can occasionally be larger (up to a maximum of 60 metres for a reconstructed intersection).

The choice of overall dimensions is in effect a compromise; the preference for smaller dimensions is governed by the following arguments:

- they offer greater versatility, especially in built-up areas, where the space available is often limited;
- cyclists and pedestrians do not have to make as large a detour round them;
- high speeds will not be possible.

Slightly larger dimensions ease the manoeuvrability of larger vehicles through the roundabouts.

The speed of vehicles entering the roundabout is reduced by constructing radial entry lanes wherever possible, combined with a fairly tight radius of curvature. The traffic lane on the roundabout is narrow, ranging from 5 to 7 metres, making it practically impossible for cars to drive side-by-side or to overtake each other

while on the roundabout. The entry and exit roads are often also single-lane. Recommended dimensions for roundabouts are as follows:

external diameter:	30.0 m	lane width:	6.5 m
width of entry lane:	3.5 m	width of exit lane:	4.0 m
radius of junction curves (entry):	9.0 m	(exit):	14.0 m

Clearly, heavy vehicles such as articulated lorries and buses will have to drive carefully through roundabouts with these dimensions. Most vehicles will have little trouble in doing so. Nevertheless, in many cases, an extra provision will be made for heavy vehicles in the form of a slightly raised strip at the outer edge of the central island covered in a different type of asphalt (1.5 to 2 metres), over which the inner back wheels can be driven. Such a roundabout can be seen in Illustration 1.

Several hundred cyclists may cross the busier roundabouts each hour; during rush hours, this number can rise to over a thousand. The number of mopeds using these roundabouts is usually between 10 and 20% of the number of cyclists. It is therefore logical that considerable thought should be given to provisions for bicycles and mopeds. In addition to roundabouts without special provisions for cyclists (Illustration 1), there are also roundabouts with separate bicycle paths (Illustration 2) and roundabouts with cycle lanes along the outer edge of the traffic lane (Illustration 3). The cycle lanes on the roundabout itself are 1.5 to 2 metres wide (a minimum of 2 metres can be recommended) and are coloured red wherever possible. The separate bicycle paths can be almost any size and are sometimes designed for two-way traffic. Mopeds usually use bicycle paths, if present; however, there are also situations in which they may or must use the main traffic lane.

As on every other type of intersection, pedestrian crossings are frequently included on a roundabout. However, pedestrians now have the added benefit of shorter crossing points (due to the narrow traffic lanes) and low traffic speeds.

3. PRIORITY RULES AND SPECIFICATIONS

On new roundabouts, the traffic on the roundabout itself has priority over approaching traffic. This rule is assisted by the radial construction of the entry lanes, and it is the combination of these two factors which reduces the approach speeds of traffic. There are also differences in the way in which the priority rule is applied to cyclists. If cyclists are on the roundabout itself, they take priority over all vehicles wanting to enter the roundabout, in the same way as cars do. However, different rules are applied to the separate bicycle paths: in most cases, cyclists must give way at each crossing point to fast-moving traffic. On one or two roundabouts with separate bicycle paths, a combined rule is applied: i.e. cyclists take priority over traffic approaching the roundabout, but must give way to traffic leaving the roundabout. This requires additional vigilance on the part of the motorist, since cyclists are often crossing in both directions.

4. PRACTICAL APPLICATION OF THE NEW ROUNDABOUTS

New roundabouts are usually constructed in built-up areas, although an increasing number are now appearing outside these areas. Transitional locations between the two types of area are found to be particularly suitable for roundabouts, especially when combined with a change in the maximum speed limit. The reason for building roundabouts is often a desire to improve safety, usually for vehicular traffic but also for pedestrians crossing a road. In some cases, an intersection with traffic lights is replaced by a roundabout on the grounds that it is a cheaper solution in which safety considerations are not compromised.

New roundabouts tend to be constructed at less busy intersections (300-500 vehicles during peak periods), but they are also sometimes built at busier junctions (up to 2,200 vehicles an hour). The vehicle flow rates cited constitute the number of cars which cross the intersection or the roundabout during the period of time mentioned, regardless of the direction of travel). The numbers of cyclists also vary significantly: between 300 and 700 cyclists can cross the busier roundabouts in an hour.

When road planners are considering whether or not to opt for a roundabout in a certain location, its anticipated effect on safety is often a decisive factor. Hesitation about whether to build roundabouts with more than one lane in locations with heavy through-traffic is an example of this. Insufficient insight into the safety aspects of such multi-lane roundabouts with priority for traffic on the roundabout originally dissuaded planners from sanctioning them. This is now gradually changing, with one or two local authorities having altered the priority rules for existing multi-lane roundabouts.

In situations where the traffic flow rate on the main road is many times greater than that of crossing traffic, roundabouts are not the preferred solution. On the other hand, roundabouts have been found to be suitable for locations where entry and exit roads connect with the main road at the point of intersection.

5. RESEARCH

A start was made on research into experiences with roundabouts in the Netherlands and other countries, such as England, Australia, France and Germany. Experiences with existing roundabouts in the Netherlands were not always positive, either in terms of capacity or safety. However, when the safety aspect was examined more closely, it emerged that this negative impression was mainly due to the number of accidents resulting in material damage only and not to the number of accidents resulting in injury. Hence the safety record of cyclists and moped-riders appeared to be much the same for roundabouts as for other intersections, although this could not be properly assessed due to the lack of sufficient information.

Experiences in other countries were largely positive, both in terms of safety and capacity. In England, however, it has emerged that attempts to provide for an increasingly large capacity has to some extent

compromised safety. Moreover, research in England and Australia showed that roundabouts were often less safe for cyclists. This last factor was the main reason which prompted us to carry out research into the safety of cyclists on roundabouts.

Our research began with a theoretical study into whether a route on or alongside the roundabout was safer for cyclists, and which priority rule would best suit them. This was followed by an empirical study in which the behaviour of both motorised traffic and cyclists on the various different types of new roundabout was observed and compared with their behaviour in the earlier traffic situation (usually an intersection with a major road).

The theoretical study indicated that the preferred option was likely to be to separate motorised and cycle traffic, i.e. the construction of separate bicycle paths. At crossing points for bicycles, cyclists would have to give way to motorised traffic. The speed of mopeds on roundabouts was found to be similar to that of vehicles, so that they could simply use the ordinary traffic lanes.

This practical study produced a variety of interesting results.

For example, it was found that the speed of motorised traffic fell dramatically at the approach to the roundabout; at around 30 metres from the roundabout, average speeds of between 30 and 40 km/h were recorded, compared to 50 km/h or more in the earlier situation. Lower speeds not only reduce the likelihood of accidents but also their seriousness. The risk of personal injury as the result of a collision between cars at these speeds is already very remote. In principle, lower speeds also contribute to the safety of cyclists and moped-riders, although the chance of injury is still present, due to their greater vulnerability. Further away from the roundabout, the reduction in speed is much less obvious but is often still measurable.

Observations of conflicts between road-users showed that the total number of conflicts were often more or less the same as before but that they were on average less serious. However, it should be pointed out that these observations were sometimes taken only a few months after the intersection had been rebuilt, whereas it has since emerged that road-users often take longer to get used to the new arrangements. The nature of these conflicts had naturally also changed, due to the fact that the intersection was now different; however, certain types of conflict, such as that between cyclists wanting to proceed straight ahead and cars wanting to turn off, were the same in both situations. A more detailed analysis of these conflict observations failed to indicate which solution would be better for cyclists.

Observations of priority behaviour showed that motorists still have more difficulty in giving way to cyclists and moped-riders than to other motorists. They also indicate that motorists in a particularly dominant stream of traffic are somewhat less inclined to give way. This could restrict the applicability of roundabouts in certain situations.

The use of direction indicators on roundabouts varies from place to place and shows little consistency; Table 1 records the observations made in one of the locations.

Intended manoeuvre	Direction indicated on entering the roundabout (in %)			on leaving the roundabout (in %)			Number of observations
	left	right	none	left	right	none	
Right turn	0	84	16	0	84	16	56
Straight on	3	3	95	0	23	77	113
Left turn	45	2	53	0	32	68	140

Table 1. Use of direction indicator by motorists on a roundabout

On average, crossing times were largely similar to the previous situation. However, the differences between crossing times for the different types of traffic movements had been significantly reduced.

Although not directly relevant for the safety of cyclists, it is nevertheless worth mentioning that these observations, together with computer-aided calculations (traffic simulation) provide a reasonably reliable picture of the capacity of these new roundabouts. The capacity of an entry road as a function of the volume of traffic on the roundabout is shown in Illustration 4. By capacity is meant the flow rate of traffic, whereby the average waiting time of traffic on the entry road is 30 seconds. The gradient of the curve deviates significantly from those often found in English graphics. This difference can be attributed to the much narrower width of the traffic lane on the new roundabouts in the Netherlands, which almost totally prevents vehicles from driving side-by-side. Depending on the division of the volume of traffic and the number of cyclists to whom priority must be given, the capacity of a new roundabout will vary between 2,000 and 2,400 vehicles per hour, which is not bad for a roundabout with such limited dimensions.

6. SURVEY OF ACCIDENTS

Although most of the new roundabouts had only been built a short time, it still seemed worthwhile to carry out an initial survey on the safety of roundabouts in general. This survey, which was carried out in 1990, was somewhat restricted in scope; however, a follow-up survey will be conducted on a wider basis this year.

The survey assembled data about accidents from 46 locations where roundabouts had been built in preceding years, of which 8 were situated outside built-up areas. The earliest roundabouts surveyed were built in 1986, while the most recent were completed in about the end of 1988/beginning of 1989, so that they had been in use for at least a year.

The situation which these roundabouts replaced was nearly always an intersection with a major road, or an ordinary junction. The traffic flow rate, insofar as it was known, varied between 250 and over 2,000 vehicles per hour during peak periods. Some of these roundabouts were built because the accident record of the earlier situation gave rise to the need for some form of safer solution. It is therefore possible that part of the improvement observed is due to the effect of

incidental negative troughs in the preceding period ('regression to the mean'). But even if these are taken into account, a significant improvement in safety can still be detected.

For the analysis of safety on roundabouts, a period of 7 months was discounted for each roundabout, i.e. the 3 months before the month in which the roundabout was taken into use (reconstruction) up to and including the three months following (habituation period). The figures in Table 2 have not been corrected to take account of general developments in road safety or changes in traffic volume, etc.

	Before (=intersection)		After (=roundabout)	
Total number of years	186.7		60.5	
	number	per year	number	per year
All accidents	1061	5.68	159	2.63
Deaths	7	0.04	0	0.00
Hospitalisations	85	0.46	4	0.07
Other casualties	225	1.21	10	0.17
Total number of casualties	317	1.70	14	0.23
Casualties				
Cyclists+moped-riders	130	0.70	11	0.18
Other road-users	187	1.00	3	0.05

Table 2. Summary of results for all 46 locations.

Allowing for the necessary reservations, it can be concluded that the total number of accidents a year at these intersections has been halved by the introduction of roundabouts. The number of casualties has dropped significantly, even by as much as 80%. The number of casualties among cyclists and moped-riders has also been considerably reduced, although by less (over 70%) than for casualties as a whole. Given the low speeds of motorised traffic on the new roundabouts, it is not surprising that the chance of injury for the driver and passengers in motorised vehicles has become very remote. It is therefore also not surprising that the majority of the relatively small number of casualties following the introduction of the roundabouts should be cyclists and moped-riders.

The results for roundabouts outside built-up areas are no less positive than the results for roundabouts in built-up areas.

Three different types of provision for cyclists can be distinguished: (a) no special provisions, (b) a cycle lane on the roundabout itself and (c) separate bicycle paths around the roundabout. Naturally, an attempt was made to ascertain whether there was a difference in safety record between these different forms. However, due to the small number of casualties recorded after the roundabouts were introduced, it was not possible to establish significant differences between the three. Nevertheless, differences were recorded between the total number of accidents per year; before the roundabouts were introduced, these

varied between 3.4 (no provisions) and 6.8 (cycle lanes) per year. After roundabouts had been built, these differences were much smaller: i.e. a minimum of 2.1 and a maximum of 2.9 per year.

7. RECENT DEVELOPMENTS

The survey of accidents in 1990 recorded extremely positive results for roundabouts; up to and including 1989, no fatalities had occurred. The situation has changed since then, with four deaths occurring in accidents on new roundabouts. In each case, the casualties were cyclists, and in at least three of the cases, the accident was caused when a lorry wanting to leave the roundabout and a cyclist wanting to continue straight ahead collided. Each accident also involved a roundabout with a cycle lane at the edge of the main traffic lane. This is therefore a major indication that this type of roundabout is not safe, though it is not conclusive, since until recently, this was also the most common type of roundabout in the Netherlands. These less positive experiences gave additional impetus to the decision to begin a new accident survey this year, this time covering 200 roundabouts. The aim is to be able to deduce from this survey which solution offers cyclists the safest option.

Another development concerns the introduction of roundabouts with two traffic lanes. Because little is as yet known about the safety of this type of roundabout in the Netherlands, planners hesitated a long time before deciding to give it the full go-ahead. However, about a year ago, one or two local authorities changed the priority rules for existing two-lane roundabouts. Occasionally, these roundabouts have also been rebuilt to give entry lanes a more radial approach. On two of these roundabouts, research is being carried out to assess the effect of the change in priority on road safety and capacity. Initial indications have been largely positive. If this trend continues, it could mean an end in the foreseeable future to the unwanted situation in which a variety of different priority rules is applied to roundabouts, as is currently the case in France.

8. CONCLUSIONS

After a somewhat hesitant start in 1986, new roundabouts are now being built in the Netherlands at an increasing rate, both inside and outside built-up areas.

In spite of their limited dimensions, the capacity of these roundabouts appears to be quite considerable; depending on the division of traffic volumes and the number of cyclists using them, they can accommodate between 2,000 and 2,400 vehicles per hour.
On the basis of the results obtained to date, it can be concluded that the new roundabouts are also safer for cyclists and moped-riders, and possibly even a great deal safer than ordinary junctions or intersections with a major road.
All three solutions for bicycle and moped traffic on roundabouts appear to have yielded positive results in terms of safety; however, the question as to which solution is the most safe cannot be definitively answered yet.

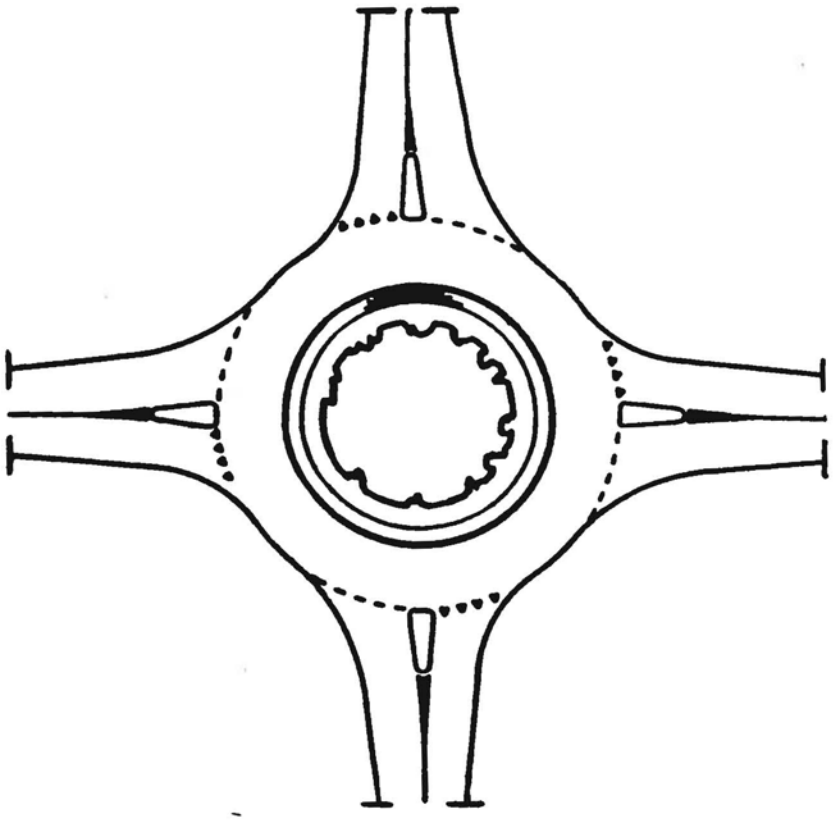

Illustration 1. Example of a roundabout with a raised strip at the edge of the central island.

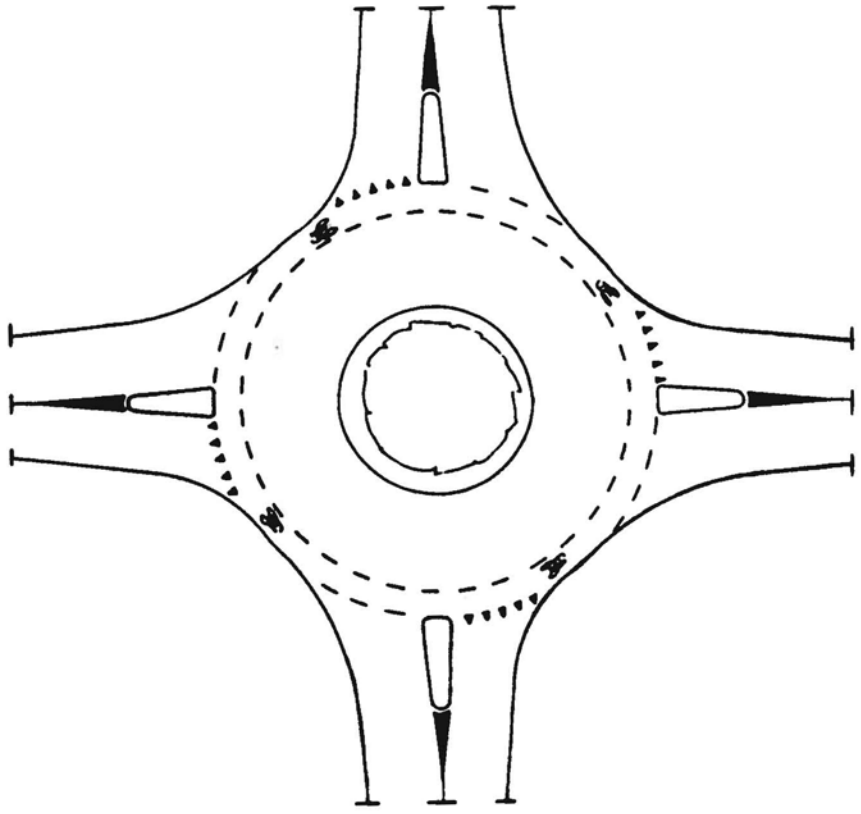

Illustration 2. Roundabout with a separate bicycle path.

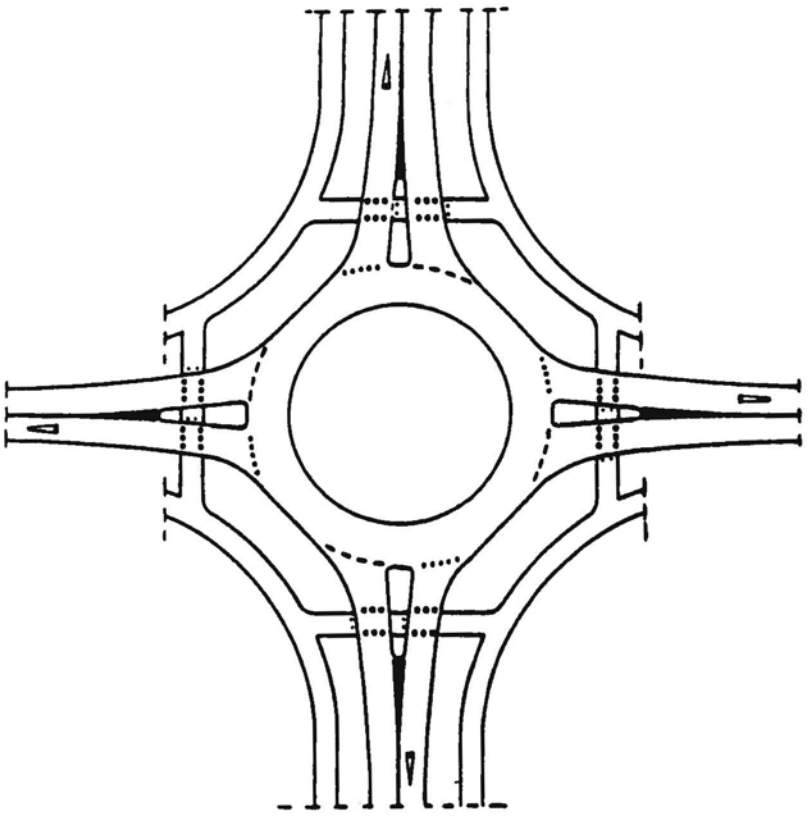

Illustration 3. Roundabout with a cycle lane.

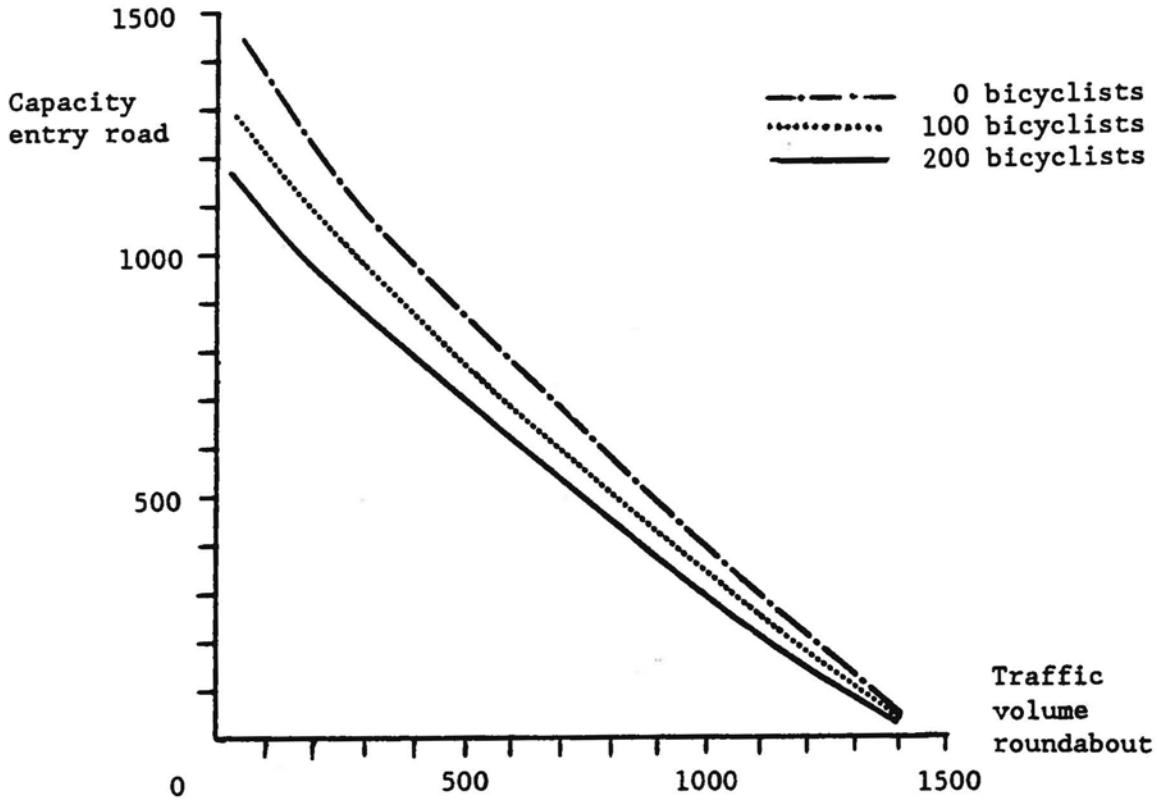

Illustration 4. The capacity of an entry road as a function of the volume of traffic on the roundabout.

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