Studies on Roundabouts in Germany: Lessons Learned

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Abstract

Germany has now 25-years of experience with different kinds of modern roundabouts. In addition to that, large conventional rotaries have been used for 70 years. Modern roundabouts include

- compact single-lane roundabouts with diameters between 26 and 40 m
- mini-roundabouts with a traversable island and diameters between 13 and 25 m
- larger roundabouts (40 –60 m) with 2-lane access for cars and single-lane operation for trucks
- turbo-roundabouts.

All these types have emerged as very successful regarding traffic safety as well as traffic performance. On the other side the traditional larger 2-lane roundabouts have significant safety problems. The paper describes the German experience from practice and from a long series of research projects regarding traffic safety, capacity, and traffic performance estimation as well as geometric design.

1. Introduction

Germany like other European countries has a long tradition of many decades regarding roundabouts. The roundabouts built between the 1930ies and the 1960ies were, however, limited in number and were mainly of a larger type (Figure 1) with several lanes, both on the approaches and exits as well as on the circle. These traditional roundabouts have many similarities to those intersections which are called "rotaries" in the North-American context. Over the years, these conventional roundabouts gained a bad reputation regarding their safety and their limitations in capacity which – in spite of the large consumption in space – did not exceed an ADT beyond 40,000 veh/day. Thus, they were no longer built after the 60ies and many of them were replaced by signalized intersections *[1]*. One of the reasons for this development is that in Germany all kinds of accidents (also damage-only accidents) are recorded by the police. The damage-only accidents are of frequent occurrence at these larger roundabouts, whereas accidents with personal injuries tend to be rather under-represented at the large roundabouts. With this kind of statistics the reputation of the larger roundabouts became worse over the years.

It was in the mid 1980ies that experiments were started with new modern roundabouts inspired by the great success of roundabouts in the UK. At that time, single-lane compact roundabouts were of primary interest. The design standards from the UK, however, have not been copied. Instead the basic principles of intersection design were applied quite consequently. These compact single-lane roundabouts became a story of great success. They are now a state-of-the-art solution as it is documented in the current guideline [2]. As a consequence, in recent years also other types of roundabouts receive more and more interest.

For further discussion some consensus about terminology seems to be useful. Therefore, Figure 2 shows which types of roundabouts are usually defined in Germany including some information about their application both regarding size and traffic volumes. In the following parts of this paper these types are discussed concerning design principles, safety, capacity, and performance of operation.

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Figure 1 : Large traditional roundabout in Munich

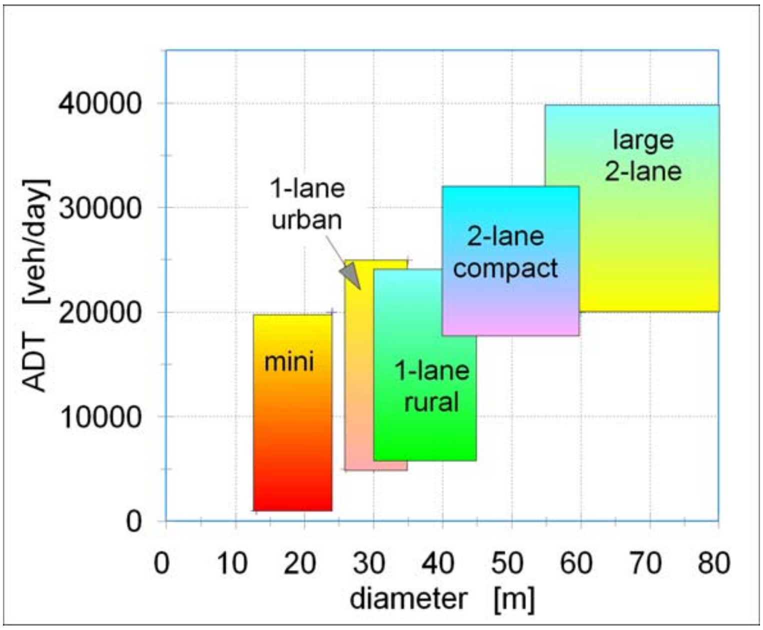

Figure 2 : Definition of types of roundabouts by their inscribed circle diameter and their maximum capacity in terms of average daily traffic (ADT)

2. Mini-Roundabouts

Mini-roundabouts have a diameter between 13 m and 24 m (measured between the curbs). Larger vehicles can override the central island as far as their swept path makes it necessary.

Experiments began in 1995 in the state of Northrhine-Westphalia with 13 intersections that were converted from unsignalized intersections into mini-roundabouts *[3]*. The success was overwhelming. They could carry up to 17.000 veh/day without mayor delays to vehicles. They could easily be built - sometimes without significant investment costs - and they turned out to be very safe. For the intersections under investigation, the overall safety results were:

		before	after (Mini)	
accident rate	AR	0,79	0,56	acc. / Mio veh
accident cost rate	ACR	9,47	3,91	€ / 1000 veh

Here it should again be emphasized that in Germany, as a tradition and according to official rules, both personal injury accidents as well as damage-only accidents are included in the police files and, thus, also in the described accident rates and accident cost rates.

Figure 3 : Mini-Roundabout in Karlsruhe

Figure 4 : Mini Roundabout in Hamburg

As a result of the investigations the following rules are recommended for application *[4]* and *[2]*:

- Application only in urban areas (maximum allowed speed = 50 km/h).
- Inscribed circle diameter between 13 and 24 m
- circular roadway width between 4,5 and 6 m
- cross slope 2,5 % inclined to the outside

- central island with a maximum height of 12 cm (in the center) above the circular lane. It is not sufficient to establish the central island just by some road markings. To convince drivers to accept the roundabout driving rules, a minimum curb height of 4 or 5 cm has been identified by experience.
- capacity up to a maximum of 20.000 veh/day
- no flaring of the entries
- only single-lane entries and exits.

Meanwhile, many mini-roundabouts have been built according to these rules, which operate quite successfully (Figure 3 and Figure 4). New research on mini-roundabouts is meanwhile going on, which is reported elsewhere in this conference by Schmotz.

Experiments with rural mini-roundabouts have also been performed. As a result, mini-roundabouts are not further recommended outside built-up areas due to safety concerns.

3. Compact Single-Lane Roundabouts

The standard type of a roundabout according to the German philosophy has a diameter between 26 m (as a minimum - better: 30 m) and 45 m. It has only one single lane on each of the entries and exits as well as on the circle. It has a central island which can not be used by traffic. Due to the needs of larger vehicles (swept path for turning) the circular roadway must be wider than a usual lane. With 26 m diameter, thus, the circular lane must be widened up to 8 m. In such cases a paved apron can be recommended for urban conditions (Figure 5). From this type approximately between 3.000 and 4.000 intersections have been built during the last 20 years both in urban and rural environments (one extreme example for a rural roundabout: see Figure 8, left).

Table 1: Accident rates and accident cost rates for compact single-lane roundabouts obtained from different reports

	before		**after**	
	Accident rate	Accident cost rate	Accident rate	Accident cost rate[2]
Brilon, Stuwe [5]	0.97	14.77	1,62	7,36
Baumert [6]				
urban			0.53	6.02
rural			0,74	10.06
Meewes [7]			0.92	8.0
	acc./10^6 veh	€/10^3 veh	acc./10^6 veh	€/10^3 veh

Many investigations have been made regarding safety of these compact single-lane roundabouts. Some of these results are summarized in Table 1.

We see rather low figures for accident rates and - especially - for accident cost rates. These numbers are around half of the corresponding rates for both normal unsignalized and even signalized intersections. Especially for rural crossroads the accident risk is only in the range of 10 % compared to an unsignalized

[2] Accident cost rates denote the accumulated economic loss caused by accidents in relation to the number of vehicles which have used the intersection. Here property damage, personal injuries, and fatalities are expressed in currency units (Euro). It is usual to value severe injuries (person has stayed in a hospital overnight) and fatalities (person died within 30 days) by their weighted average. The rules for the calculation are defined in *[26]*.

intersection. The excellent accident records of compact roundabouts are believed to be mainly due to the low speed level of all drivers within the intersection. Thus, a speed reducing design is favored by the guidelines *[2]*. That means:

- Intersection arms should be directed to the center of the roundabout in a manner rather rectangular to the circle. No tangential entries are allowed. This improves the visibility of the intersection for the approaching driver and causes reduced speeds.
- The curb transition between the entry lane curbs and the circle should follow circles with a small radius (e.g. 12 -16 m for entries and 14 - 18 m for exits). Of course, details must be adjusted to the swept path curves of the largest allowed heavy vehicles, e.g. by using a software tool like AutoTurn *[8]*.
- Moreover, the circle lane should be inclined to the outside (2,5 %). This enables drainage as well as a better visibility for the approaching driver. It reduces driven speeds on the circle.

Figure 5 : Compact single-lane urban roundabout (left side: prototype-like design)

For pedestrians and cars the compact roundabout seems to be the safest type among all types of intersections *[7]*. For pedestrians the walkways crossing the entries and exits should be built in a distance of 4 to 5 m away from the margin of the circle. Zebra crossings (which impose an absolute right of way for pedestrians in Germany) should be installed in urban areas according to the guidelines *[2]* (see Figure 5). This rule is mainly due to the fact that zebra crossings are demanded by the public. But in most cases they are not of a real advantage to the pedestrians. Also without zebra crossings the pedestrians have no delays neither at entries nor at exits of a roundabout. Also accidents with pedestrians are quite seldom at single-lane roundabouts.

The only remaining significant risk at a compact roundabout occurs in connection with bicyclists. For cyclists the design has to be made with special care. Cycle lanes at the peripheral margin of the circle are not allowed since they have proven to be very dangerous to cyclists. Up to a traffic volume of about 15,000 veh/day, cyclists can be safely accommodated on the circular lane without any additional installations in urban areas (Figure 6). Even if the approaching arms of the intersection are equipped with separated cycle tracks the two-wheelers are guided to the normal traffic lane on the approach to carry the cyclists through the single-lane roundabout and leading them back on a cycle track after leaving the intersection into the desired direction.

Above the volume of 15,000 veh/day, separate cycle paths are regarded to be useful. These, however, should also have a distance of around 4 to 5 m from the circle at the point where they are crossing the entries and exits. In a closer distance the visibility of cyclists is impeded for the drivers of vans or trucks. If cycle paths are designated to be used for both directions, special road markings are required. At rural roundabouts separate cycle tracks are recommended in each case. Here cyclists should yield to motor vehicles at the crossing points to assign more responsibility for their own safety to the cyclists themselves (see Figure 7, right side).

Figure 6 : *Operation of bicycle traffic on the circular roadway for traffic volumes below an ADT of 15,000 veh/day. Due to similar desired speeds (in a range between 15 and 25 km/h) of cars and cyclists no overtaking is required. Cyclists can indicate their intended direction of driving clearly by their trajectory through the intersection.*

Figure 7 : *Bicycle track combined with a zebra-crossing (urban, left) and combined with walkway (rural, right). In the urban context cyclists have the right of way whereas at rural intersections cyclists have to yield to motorized traffic.*

The Roundabout on the right replaced an intersection with many severe accidents.

Figure 8 : *Rural single-lane roundabout (left side: with three bypass-lanes)*

A lot of more details should be taken into account for a safe traffic operation at a compact roundabout [2]. Mistakes in design usually cause more accidents, where the cyclists suffer at most from these risks.

4. Compact two-lane roundabouts

There was always a rather restrictive view in Germany on new large roundabouts in the style of Figure 1. The restrictions are based on bad accident experience. They are, however, demanded by the public. As a first approach towards larger roundabouts, a new intersection type has been created: The compact semi-two-lane circle. Ideas for this type were described in a preliminary document from 2001 *[9]* and consequently this new type was built by several municipalities and highway authorities. In succession an investigation on this new type has been performed on behalf of the federal DOT *[11]* which lead to the acceptance of this compact two-lane roundabout by the guideline from 2006 *[2]*. Thus, these roundabouts are now state-of-the-art solutions.

Figure 9 : Urban compact two-lane roundabout in Oberhausen

Figure 10 : Rural compact two-lane roundabout in Bad Aibling

The design of compact two-lane roundabouts is similar to the concept of single-lane roundabouts. The main difference is the width of the circle lane. It is wide enough for passenger cars to drive side by side, if required. However, the circle lane has no lane marking. Large trucks and busses are forced to use the whole width of the circulatory roadway making their way through the intersection. The fundamental characteristics of these compact two-lane roundabouts are:

- outer diameter: 40 to 60 m
- circle lane width: 8 to 10 m ; without lane marking (to prevent drivers from overtaking)
- single- or two-lane entries according to traffic volumes
- single-lane exits only.
- No bicyclists are allowed on the circle lane.

This type of design is not aiming for the avoidance of vehicle path overlap. Different from the US approach *[10]* there is not the concept of the "natural trajectory" of vehicles within the German sophistication. The basic consideration is: The geometry of the roadway must provide space for all vehicles to drive through the intersection. If however, several vehicles compete for space then the drivers must take care of each other. Thus, at a compact two-lane roundabout a large vehicle claims for the whole width of the circular roadway. Car drivers must avoid interfering with them. Also parallel driving of cars is unusual. The wider space, however, allows some kind of staggered driving. This style of design is aiming for an improved safety since it requires lower speeds as well as mutual attention and care of road users.

After opening of such a roundabout there may be some minor complaints by the public regarding limited space. But after a short while drivers learn and accept the required kind of behavior.

Warrants for the size of a roundabout are:

- If capacity allows, only single-lane roundabouts should be built.
- If such a type does not match the required capacity, an enlargement should be tested in the sequence:
    1. Bypass lanes (separate right-turn lanes)
    2. Compact two-lane circle with single-lane entries
    3. Two-lane entries where necessary

Each unnecessary enlargement should be avoided due to safety reasons.

The research project *[11]* investigated driver behavior by speeds, conflicts, and test drives with a sample of different drivers. Moreover, accidents (before / after), capacity, and public opinion have been studied at a couple of these compact two-lane circles.

The essential results are that compact two-lane roundabouts are also very safe intersections. In fact, the accident rate is only a little bit above the rate at compact roundabouts with one lane in the circle. Also, most accidents at these sites remain without personal injuries. The safety is particularly high if all entries of the roundabout have only one lane and if the volumes of pedestrians and cyclists are low. These results have been confirmed by a new investigation in 2010 *[12].*

5. Larger Roundabouts

Above this new semi-two-lane type – which by the way is very similar to what other countries like France or Switzerland have built for years as normal single-lane "giratoires" – there are still the larger conventional two-lane roundabouts like the one in Figure 1. The capacity of these larger roundabouts are rather well investigated (cf. *[15] and* Figure 13). The high capacities reported by the upper curve in Figure 13 can only be applied for cases, where the exits provide two lanes. This type of a roundabout is, however, not recommended - neither by guidelines nor by expert's advice - in Germany due to the experience that two-lane exits systematically cause a large number of accidents. Thus, two-lane exits are a safety problem at these larger types of roundabouts. Due to interactions of circulating flows with fast vehicles leaving the circle from the inner lane, these two-lane exits often are a reason for injury accidents. Therefore, multi-lane roundabouts are not recommended for application in Germany.

Especially 2-lane exits are completely banned. Also three-lane (or larger) unsignalized roundabouts are not under consideration in Germany. This is highly correlated to the kind of traffic rules in Germany. It should be noted that in Germany, like in other countries on the European continent there is no traffic rule for the interaction between vehicles on the circular lanes.

Figure 11 : *Typical driver behavior at a compact two-lane roundabout: The left entry lane is not accepted. Drivers are afraid of conflicts when leaving the circle from the inner lane.*

Figure 12 : *Turbo-roundabout in Baden-Baden*

It can be expected that new experiments will come up in Germany in the future also with larger roundabouts, e.g. with spiral markings. One idea for such a larger roundabout is the type of a so-called Turbo-Roundabout. The first Turbo-Roundabout has been built in 2006 in the town of Baden-Baden *[13]* (see Figure 12). Here, vis-a-vis from the mayor entries a second lane is added on the inner side of the ring, whereas at exits with a significant exiting flow the vehicles on the outside lane are forced to continue their way into the exit. This type could be of special benefit at locations where the through traffic has larger volumes. This type is mainly in use in the Netherlands where it has been invented by Bertus Fortuijn. There however, curbs are used to separate the lanes within the circular roadway, a solution which is not accepted in Germany due to safety and winter service considerations.

Recently a research project on such Turbo-roundabouts has been finished *[12]*. The result was that the Turbo-roundabouts offer the potential to combine a level of safety like the compact roundabouts with larger capacities. Meanwhile several examples of this type have been built as a kind of experiment. Recently also a committee by FGSV[3] has been established to decide on an adequate design and to integrate this solution into the guidelines.

It should be noted that these Turbo-roundabouts are only called by their special name in Central Europe. In the US guidelines (e.g. *[10]*, exh. 6-26) this type is not denoted by a special term. Here they are treated like a quite normal solution.

What can also be reported is that signalized multilane roundabouts have proven to be a good solution in specific situations. Experiments at sites with volumes up to 50000 veh/day were successful both from the view of high capacities (cf. Table 3) and traffic safety *[14]*.

6. Capacity of roundabouts

In Germany the capacity of roundabouts has been studied over many years by a series of investigations. For all types of roundabouts, except the Mini, capacities of entries to the circle have been established as independent from the flow at the other entries. Both gap acceptance theory and the empirical regression method have been in the scope of these investigations. Initially there was a preference on empirical linear regression approaches for capacity depending on circulation flow with a distinction by the number of lanes (entry and circulating) *[5]*. Here also a multivariate regression approach using geometric features of the intersection according to the British example has been developed *[15]*. This solution was not too successful, since it was too much focused on the specific combination of parameters, which were the basis of calibration. The full range of possible parameter values could, however, not been covered by sufficient samples of observed cases. As a consequence, the multivariate regression equations had a tendency towards a significant misjudgment under combinations of parameter values as they had to be used in practice. Thus, this approach is not further followed.

The currently established official procedure is more related to gap acceptance. It uses Tanner's *[16]* equation in a form which was adjusted to the necessities of roundabout analysis by Wu *[18]*:

$$C = 3600 \cdot \left(1 - \frac{t_{min} \cdot q_k}{n_c \cdot 3600}\right)^{n_c} \cdot \frac{n_e}{t_f} \cdot e^{-\frac{q_k}{3600} \cdot \left(t_g - \frac{t_f}{2} - t_{min}\right)} \tag{1}$$

where

C	=	basic capacity of one entry	[pcu/h]
q_k	=	traffic volume on the circle	[pcu/h]
n_c	=	number of circulating lanes	[-]
n_e	=	number of entry lanes	[-]
t_g	=	critical gap	[s]
t_f	=	follow-up time	[s]
t_{min}	=	minimum gap between succeeding vehicles on the circle	[s]

As it can be obtained from the equation, the capacity of each entry depends – of course - on the circulating traffic flow (q_k) and on the number of lanes within the circle as well as at the entries. Other geometrical details did not show an important impact on capacities. This is also true for the width of the splitter island, which is used in formulas from Switzerland and France.

3 FGSV (in Cologne, Germany: www.fgsv.de) is a private non-profit organisation which develops and edits guidelines and standards regarding highways and road traffic by voluntary work of experts recruited from practice and science. These guidelines usually are introduced as mandatory by the federal and state highway administrations.

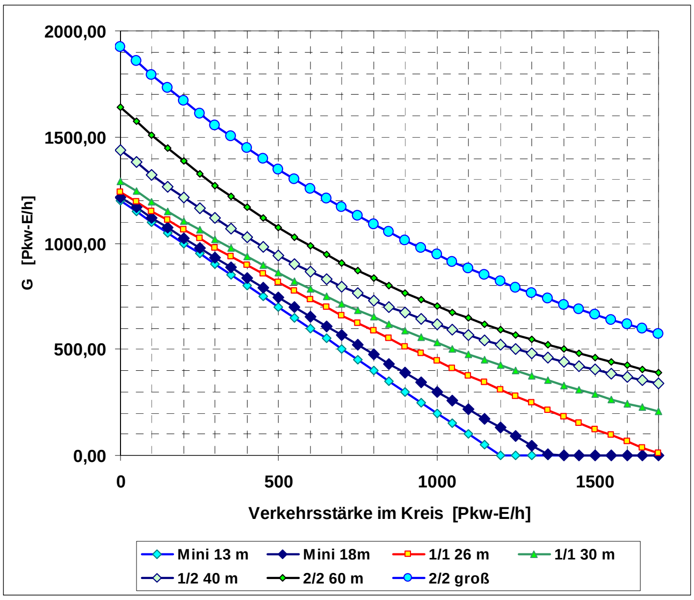

Figure 13 : Entry capacity of roundabouts according to [17]. The numbers indicate the number of lanes: entry/circle together with the inscribed diameter in meter (groß = larger than 60 m).

Table 2 Parameters for capacity calculations according to [17]

Type of roundabout		n_e	n_k	t_g	t_f	t_{min}
				eq. 1 with the following parameters:		
Mini $13 \le d \le 26$ m 1)		1	1	$t_g = 3{,}86 + \frac{8{,}27}{d}$	$t_f = 2{,}84 + \frac{2{,}07}{d}$	$t_{min} = 1{,}57 + \frac{18{,}6}{d}$
1/1 $26 \le d \le 40$ m 2)		1	1			
1/2 $40 \le d \le 60$ m 1)		1	2	$C = 1440 \cdot e^{-\frac{q_k}{1180}}$		
2/2 compact $40 \le d \le 60$ m 3)		2	2	$C = 1642 \cdot e^{-\frac{q_k}{1180}}$		
2/2 large d >> 60 m 1) 4)		2	2	$C = 1926 \cdot e^{-\frac{q_k}{1405}}$		

1) : d = inscribed circle diameter [m]
2) : for d > 40 m: d = 40 m has to be used
3) : If d > 60 m but all other characteristics of a compact two-lane roundabout according to the guideline *[2]* are fulfilled, then d = 60 m should be used.
4) : plus 2 complete and separate lanes (with lane marking) plus full-capacity exits

For the use of these equations the volumes are measured in passenger car units (pcu) with: 1 truck = 1.5 pcu; 1 articulated truck = 2 pcu, 1 motor bike = 1 pcu[4], and 1 bicycle (on the roadway) = 0.5 pcu. For the three parameters t_g, t_f, and t_{min} constant values have originally been taken from observations by Stuwe *[5], [15]*. However, by these parameters not all kinds of roundabouts could be treated. Thus, Brilon, Wu

[4] Different from rules in other countries the consumption of road space at roundabouts by motorcycles was found to be comparable to one passenger car.

(2008) *[17]* have proposed a modified version for the introduction of the parameters t_g , t_f , and t_{min} into eq. 1. Here these parameters are depending on the diameter of the roundabout for Mini and 1-lane roundabouts as indicated in Table 2. For larger roundabouts the capacity formulas are given directly (lower 3 lines of Table 2) without the need to go back to eq. 1.

Results for the capacity of an entry to the roundabout as it depends on circulating flow according to this solution are illustrated in Figure 13. These are the capacity calculation methods as they are going to be integrated into the future German guidelines HBS 201X (the new version to replace *[19]*).

For Turbo-Roundabouts, a capacity estimation method has been developed by *[12]*. This solution distinguishes between the different kinds of lane configurations at the entry. For the typical turbo-entry (2 entry lanes and 1 circulation lane) the parameters in eq. 1: t_g =4.5 s, t_f =2.5 s, and t_{min} =1.9 s have been calibrated to be applied for each of the two entry lanes. Then the distribution of arriving traffic by lanes is

$$q_{left} = \max\begin{cases} q_{left,0} \\ q \cdot \left(0.5 - \dfrac{C_{reserve}}{6670}\right) \end{cases} \qquad (2)$$

$$q_{right} = q - q_{left}$$

where

q	=	total flow on the entry	[pcu/h]
q_{left}	=	traffic volume on the left entry lane	[pcu/h]
$q_{left,0}$	=	volume of traffic which is forced to use the left entry lane according to lane configuration (left turners)	[pcu/h]
q_{right}	=	traffic volume on the right entry lane	[pcu/h]
$C_{reserve}$	=	$2 \cdot C - q$ = reserve capacity of the entry (C according to eq. 1)	[pcu/h]

Then the traffic performance can be estimated for each entry lane separately.

To ease capacity calculations the computer program KREISEL, which can also apply capacity calculation procedures as they are reported from many other countries, is in frequent use *[20]*.

Table 3 Range of capacities for roundabouts given in ADT-values

	Number of lanes entry / circle :	1/1	compact 2/2	large 2/2	signalized 2/2[5]
a	Roundabout has sufficient capacity under all circumstances up to a volume of →	15 000	16 000	20 000	
b	Maximum possible capacity under favorable external conditions →	25 000	32 000	35 000 - 40 000	50 000 - 60 000
		veh/day			

By these methods one can also determine maximum allowable daily volumes for the total intersection according to Table 3. For an ADT between the values in row a) and b) more detailed capacity calculations are required according to eq.1 or Figure 13.

[5] This means a fully signalized roundabout with two entry lanes and two circulating lanes. Here also two-lane exits are allowed. For further details see: *[14]*

Again it should be emphasized that eq. 1 which – in its general form - is obtained from gap acceptance theory, in this context, is only used as a regression function where the parameters t_g, t_f, and t_{min} are estimated from empirical capacity data applying regression techniques. Here entering traffic volumes observed during saturated 30-s-intervals are correlated to the circulating flow within the same intervals by least square-error technique.

It should also be mentioned that a method is available from the German guidelines *[19]*, which estimates the effect of pedestrians (crossing the entries) on capacity based on research by Stuwe *[15]* which is also described in the FHWA roundabout guide *[10]* and the new HCM 2010 *[22]*.

It becomes clear that the German capacity estimation methods are different from those in other countries. Experience shows that the capacity of roundabouts is significantly influenced by basic driver behavior patterns formed by different traffic rules, traditions, and cultural attitudes. Therefore, one should not transfer capacity calculation formulas from one country to another without empirical evidence generated in the country where the method is meant to be applied. The special German attitudes e.g. are characterized by a culture of driving in lanes. It is also a basic rule of behavior here, that a road user, who has the right of way, should make use of his priority in usual cases.

In addition to capacity the quality of traffic operation at the roundabout is of primary interest. For the assessment of traffic flow performance, the average delay for vehicles entering the intersection is used as it is the case in other countries, e.g. in the HCM *[21]*. This delay usually is calculated by the Akcelik, Troutbeck equation *[23]* which is also used in the HCM 2000 (*[21],* as eq. 17-38). More recently also the formula

$$d = \frac{3600}{C} + \frac{900}{C} \cdot \left[\sqrt{(R \cdot T - 2)^2 + 8 \cdot C \cdot T} - (R \cdot T + 2) \right] \qquad (3)$$

where

d	=	average delay (queueing delay) per vehicle	[s]
C	=	capacity	[pcu/h]
T	=	duration of the peak period	[h]
R	=	C – q = reserve capacity	[pcu/h]
q	=	total volume (demand)	[pcu/h]

developed by Brilon [24] is going to be used to estimate the average delay at the entry to a roundabout.

7. Conclusions

Roundabouts have become one of the most attractive type of intersections in Germany. Reasons are the rather high traffic safety, low delays, and the popularity among politicians and in the public. Meanwhile there is much practical experience, which leads to a well sophisticated set of rules for roundabout design *[2]*. The general concept of geometric design is aiming for a speed-reducing layout which should contribute to a high safety standard. Thus, the compact single-lane roundabout is the standard solution for a roundabout. This type usually provides a better traffic performance than a signalized intersection of similar size.

Meanwhile the capacity of the standardized types of roundabouts can rather well be described. However, in any case also the larger types of roundabouts do not exceed a total capacity beyond 40,000 veh/day. Thus, for larger traffic demand the signalized intersection still is a well accepted solution. But below this margin of capacity various kinds of roundabouts are built by increasing number in Germany. An good documentation of the state of the art has also been published by the large German Automobile Club ADAC *[25]*.

Further intentions of the responsible committee of the FGSV regarding roundabouts are to follow the current rules as they are described in the paper. These will, however, be completed by specific rules for Turbo-roundabouts.

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