Roundabouts

Fuel Consumption, Emissions of Pollutants, Crossing times

Peter Züger, Dipl. Ing. ETH, TCS, Technique and Environment
André Porchet, lic. sc. nat., TCS, Technique and Environment

Conference paper STRC 2001
Session Emissions

STRC | 1st Swiss Transport Research Conference
Monte Verità / Ascona, March 1.-3. 2001

Roundabouts

Fuel Consumption, Emissions of pollutants, Crossing times

Authors	Peter Züger, André Porchet, Daniel Burch
Department	Technique and Environment
Organisation	Touring Club Switzerland
City	Emmen/Lucerne
Phone	++41/41/267 18 35 or ++41/41/267 18 24
Fax	++41/41/267 18 12
E-Mail	pzueger@tcs.ch or aporchet@tcs.ch

Abstract

Traffic roundabouts are in high favour with traffic engineers. Where traffic flow at street crossings used to be regulated by traffic lights (LSA), roundabouts are now the favoured option. Also at crossings where the right of way is regulated without using traffic lights, roundabouts are often the preferred solution nowadays. In most cases, the expected increased traffic safety, improvement of traffic flow and more economical maintenance has led to roundabouts.

This has been taken as the occasion for carrying out a research project, in co-operation with the Federal Office for Roads (Astra), into the effects of this type of traffic regulation and direction on emissions of pollutants, fuel consumption and crossing times of the cars passing through.

Questions relating to traffic safety, noise and other important aspects form no part of this study. The research work is also not concerned with giving a comprehensive view of the traffic roundabout. The measurements made with the «**M**obile **A**bgas**M**ess**A**nlage (MAMA)» (Mobile exhaust gas measurement apparatus) are the central concern of this study.

After five suitable crossings had been selected, the measurement journeys for the «before» situation were carried out, i.e. «crossing». Some months after the conversion to roundabouts analogous measurement journeys were carried out for the «after» situation, i.e. «roundabout».

The evaluation of the results showed no unambiguous trend in the effects of the conversions from crossing to roundabout. The effects of conversion of a crossing to a roundabout on crossing times, fuel consumption, emissions of pollutants etc. depended very much on local factors such as the amount of traffic, frequency of interruption of traffic flow by pedestrians, the ratio of traffic density on the different branches etc. Since the traffic density varies greatly during the day at most roundabouts, a roundabout can have a favourable effect at certain times of day contrasting with an unfavourable effect on the variables mentioned at other times.

The effects are favourable where a light-controlled crossing is replaced by a roundabout. When a roundabout replaces a crossing without light signals the effects on fuel consumption and harmful emissions are often unfavourable, since the roundabout disturbs previously uninterrupted travel.

The vehicle which carried the MAMA is one single car. The findings from the MAMA measurements can be extrapolated to the majority of the cars in Switzerland in the trend of their relative significance.

Differences given in percentages can put a result in a completely different light from differences stated in absolute terms. The emissions and absolute emission differences of a car with catalyst and the performance demanded from the motors are very small at the speeds travelled within this research project. The differences expressed as percentages can, on the contrary, be considerable.

The effects on immissions are significantly smaller than the relative differences in the emissions of private cars. Replacing a crossing with a roundabout can have little effect on the local immission situation. Regional effects cannot be found.

Keywords

Crossing – emission – fuel consumption – Monte Verità – pollutant – roundabout – STRC 2001 – Swiss Transport Research Conference – TCS

Abstract in French

Pour les planificateurs de la circulation routière, les giratoires tiennent le haut du pavé. Si, par le passé, la régulation du trafic aux carrefours se faisait à l'aide de feux de circulation, de nos jours les giratoires ont pris leur place. Mais aujourd'hui, même aux carrefours avec priorité et sans feux de circulation, les giratoires ont souvent la préférence. Dans la plupart des cas, ce sont des demandes pour une plus grande sécurité routière, une amélioration du flux du trafic et des frais d'entretien plus avantageux qui poussent à recourir au giratoire.

C'est état de choses a eu pour effet qu'un projet de recherche, en collaboration avec l'Office fédéral des Routes (OFROU), a été mis sur pied pour déterminer quelle est l'influence de ce type de régulation du trafic sur les émissions polluantes, la consommation de carburant et les heures de passage des voitures particulières qui y circulent.

Toutefois, des questions sur la sécurité routière, sur le bruit et sur encore bien d'autres aspects importants ne font pas partie de cette étude. Le propos de ce travail de recherche n'est pas non plus de donner une vue d'ensemble complète sur le thème des giratoires. Il s'agit avant tout d'effectuer des mesures au moyen de la station mobile de mesures des gaz d'échappement (**M**obile **A**bgas**M**ess**A**nlage) appelée MAMA.

Après avoir sélectionné cinq carrefours adéquats, des parcours de mesure correspondant à la situation avant – c.-à-d. «carrefour» – ont été effectués. Quelques mois après la modification du carrefour en giratoire, des parcours de mesure identiques correspondant à la situation après – c.-à-d. «giratoire» – ont été réalisés.

L'évaluation des résultats démontre qu'il n'y a aucune propension manifeste à modifier un carrefour en giratoire. Les répercussions de la transformation d'un carrefour en giratoire sur les heures de passage, la consommation de carburant, les émissions de polluants, etc. sont fortement dépendantes de facteurs individuels comme le volume de trafic, la fréquence de l'interruption du flux du trafic par les piétons, le rapport des fréquences du trafic sur les axes routiers entre eux, etc. Etant donné que la fréquence de trafic pendant la journée varie fortement pour la plupart des giratoires, il en résulte qu'un giratoire peut avoir des incidences positives à certaines heures mais par contre des incidences négatives à d'autres.

Si un carrefour doté de feux de circulation est remplacé par un giratoire, les répercussions seront positives. En revanche, si le giratoire remplace un carrefour sans feux de circulation, les répercussions sur la consommation et les émissions de polluants seront le plus souvent négatives car le giratoire perturbera un mode de conduite auparavant homogène. Les ralentissements et les accélérations forcés (et voulus pour la sécurité routière) par le giratoire génèrent une plus grande consommation et des émissions de polluants plus élevées.

Le véhicule tracteur de la station mobile de mesure MAMA était une seule et unique voiture. Les conclusions faites lors des mesures exécutées avec la station mobile de mesure MAMA peuvent être extrapolées de manière relative à une grande partie du parc automobile suisse.

Des divergences en pourcentage peuvent donner un résultat tout autre que des divergences en valeurs absolues. Lors des vitesses parcourues dans le cadre de ce projet de recherche et des performances exigées au moteur, les émissions et les différences des émissions absolues d'un véhicule avec catalyseur sont très faibles. Les divergences exprimées en pourcentage peuvent par contre être considérables.

Les répercussions sur les immissions sont nettement moins importantes que les différences relatives lors des émissions des voitures particulières. Le remplacement d'un carrefour par un giratoire a tout au plus une influence minime sur la situation des immissions au niveau local. Des répercussions au niveau régional ne sont pas constatables.

1 Measurement plan

1.1 Introduction

Where in the past traffic flows at street crossings used to be regulated by light signals (LSA), roundabouts are now the favoured option. Also at crossings where the right of way is regulated without using traffic lights, roundabouts are often the preferred solution nowadays. In most cases, the following expectations led to roundabouts: increased traffic safety, improvement of traffic flow and more economical maintenance costs.

The plan for measurements at roundabouts was discussed with various experts from the Swiss Technical Universities at Zürich and Lausanne, the Swiss Material Testing and Research Institute at Dübendorf (EMPA) and the Advisory Office for Prevention of Accidents (bfu).

The measurements described here show the effect of this type of traffic control on emissions of pollutants and the fuel consumption of private cars. Questions of crossing time and speed patterns were also investigated.

Questions of traffic safety, noise and other important aspects form no part of this study. The research work is also not concerned with giving a comprehensive view of the traffic roundabout. The measurements made with the **M**obile **A**bgas**M**ess**A**nlage (MAMA) (The Mobile Exhaust Gas Measurement Apparatus) are the central concern of this study.

MAMA makes it possible to measure consumption and emissions of pollutants directly within traffic. This unique facility is used to answer the questions of differences between different designs for traffic nodes. Using MAMA, a direct comparison of the conditions at crossings and at traffic roundabouts can be made.

At five different traffic nodes, measurement trips were made with the Mobile Exhaust Gas Measurement Apparatus before and after their conversion to roundabouts. The results are to give more clarity on the questions of environmental relevance of roundabouts compared with crossings with or without traffic lights, not only to administrative offices but also to politicians and to the public.

1.2 Aims

The following questions are to be answered by means of well-directed investigations and safe measurement results:

- What happens to the emissions of carbon monoxide (CO), carbon dioxide (CO2), hydrocarbons (HC) and oxides of nitrogen (NOx) in travelling over a nodal point, designed firstly as a crossing regulated with traffic lights or with regulated right of way without lights, and then as a roundabout?
- What happens to fuel consumption on these journeys?
- How great an effect does the type of crossing (conventional or traffic roundabout) have on crossing time?
- How does driving behaviour depend on the type of crossing (conventional or roundabout)? Driving behaviour is expressed in average speed, the way travel time is distributed between the four driving states, stop, constant speed, acceleration, deceleration and the distribution of the speeds travelled. In addition, thanks to the kinetic parameters being recorded every second, speed/time and speed/distance graphs can be produced.
- How great an effect does the amount of traffic have in the parameters considered?
- What significance and consequences has the ratio of relative traffic flows in the different branches?

2 The Mobile Exhaust Gas Measurement Apparatus (MAMA)

The Mobile Exhaust Gas Measurement Apparatus consists of three parts. Part 1 is the carrier vehicle. For the measuring trips this was a VW Golf with a 1.8 litre engine, fuel injection and three-way catalyst. The equipment can also be built into a different vehicle. The analytical equipment can be called Part 2. The four components of this equipment allow very precise analysis of the carrier vehicle exhaust gases occurring during the trip.

The computer is Part 3. Together with precise information on speed and consumption, it calculates the required data from the concentrations of emission provided by the analytical unit.

During the trip on a course carefully planned with regard to various criteria, the consumption and exhaust gases were continuously measured. At the end of a measuring trip, the values of the individual parameters are available in the desired form. A decision on how often to cover the selected course is made on statistical grounds.

The MAMA is a measurement unit worth 500,000.– Swiss Francs. This very exclusive equipment (there is only one other unit of this type at an equally high state of technical development in Europe, at Volkswagen in Wolfsburg) makes it possible to compare emissions of pollutants directly in traffic. Up to now it was only possible to make such measurements at a reasonable cost by simulation on a test rig.

Comparisons of the results from MAMA with those of various vehicle groups have shown that trends of the results of the mobile equipment in comparative measurements, as in the present case, can be extrapolated for a large proportion of all the private cars in Switzerland [3].

3 General Remarks on Traffic Roundabouts

3.1 Significance of measurements at traffic roundabouts

Directing and controlling traffic by means of roundabouts has a long tradition in England and France («giratoire, rond-point»). This type of crossing has only been re-discovered in Switzerland in recent years.

Traffic engineers and public institutions are increasingly confronted with the question of the effects of roundabouts on exhaust gas emissions and fuel consumption.

There are sometimes contradictory notes to be found in the literature, on traffic safety, noise, crossing time and other criteria. There is a great lack of information on the effects on pollutants and fuel consumption. While it is generally assumed that traffic at a roundabout not only flows better than at a crossing with or without traffic lights, but also has lower pollutants and lower fuel consumption. However, no results of exact investigations are available.

3.2 Advantages of traffic roundabouts

There are numerous publications on the subject of traffic roundabouts. A detailed research of the literature from all available sources on all possible aspects concerning roundabouts would need great expenditure. The present research task concerns pollutants, fuel consumption and crossing times. The following general advantages and disadvantages compared to a crossing with or without traffic lights were found in a simple research of the literature.

- Fewer and less severe road accidents (due to lower speeds)
- Lower cost of accidents
- Shorter waiting times before getting on to the roundabout
- Less noise, due to reduction in braking and accelerating
- More freedom in designing local layout
- Less space required than for crossings with slip roads
- Lower building costs
- Lower maintenance costs compared with traffic lights
- Generally higher vehicle capacity, but depending on situation
- Increased availability of travel routes since complete reversal of direction is possible even by buses and lorries
- Forms of junction can be adapted to the local situation, e.g. for adding more roads
- Fewer traffic signals needed than for road branching with light signals
- Making the transition into built-up areas more noticeable (gate effect)
- Greater quality of appearance of locality

3.3 Disadvantages of traffic roundabouts

- Less opportunity to favour public transport or fire brigade and ambulance (but possible, using a bus lane or a lane passing the roundabout tangentially, or by light signals)
- No possibility of affecting traffic (“green wave”)
- Greater risk to cyclists and pedestrians due to less clear distinction of traffic space
- No light signals for pedestrians
- Unpleasant for passengers in public transport buses if the roundabout radius is (too) small
- Sometimes a hindrance to heavy-transport traffic
- Limited performance, especially of two lane roundabouts.

4 Measurement program

4.1 Measuring places

4.1.1 Before and after measurements

Before and after measurements at the same place are ideal. Measurements are first made with or without the traffic signal device. After conversion, measurements are taken again but now with the traffic circulating round. That can only be, when there is a project for converting conventional crossings to roundabouts and when there are suitable conditions for carrying out measurements.

The comparison of measurement results taken at a crossing and at a similarly planned roundabout, which are completely unrelated, does not fulfil the purpose since even small differences can have serious effects on pollutants and fuel consumption. Within this research project the only traffic nodes selected for measurements were those at which before and after measurements could be made.

4.1.2 Traffic density

Traffic density is a factor of great importance in planning to use roundabouts. Different roundabouts are not equally suitable for large and small densities of traffic. If the density exceeds a certain value, traffic flow is better controlled by lights. Measuring places with different traffic densities were therefore selected.

The ratio of traffic densities on the different road branches to each other is also to be taken into account when the results of measurements are interpreted. The ratio between main traffic direction and the subsidiary direction or directions is of great importance for the effects expected from building a roundabout [6]. The standard of the Association of Swiss Road Specialists (VSS) for roundabouts [32] proposes that a crossing should only be replaced by a roundabout if subsidiary flow is at least 20 % of the main flow.

4.1.3 Position of the roundabout

The position of the roundabout can have an effect on the results of the investigations. There are different outline conditions in a village, a town or in the open country. The presence of pedestrian crossings, the composition of the traffic (cycles, mopeds, scooters) or visibility can have an effect on the measurement results.

4.1.4 Dimensioning the roundabout and central island

Because of the existing frequency distribution of external diameters of roundabouts, those with an external diameter of 32 to 40 m are to be selected as representative in out-of-town roundabouts. Those with diameters between 24 and 32 m are representative of in-town roundabouts. Mini-roundabouts with an external diameter of less than 24 m were ignored.

The central islands should be constructed so that they cannot be driven over and so that the necessity of turning makes the motorist reduce speed to about 35 km/h (turning angle β between 20° and 40° [7]).

1.1.5 Driving direction via the roundabout

Traffic roundabouts mostly have three to five branches. The density of traffic on the individual branches can differ widely. For example, the greater part of passing traffic may go straight on round the roundabout (180°). It may also happen that the greater part of the traffic turns left (270°).

The effects on the main stream are usually greater than those on the subsidiary stream, since in most cases the main stream could previously continue without hindrance, or was favoured by traffic controls. It is conceivable in certain conditions that the effects of conversion may be clearer for a subsidiary stream than for the main stream at the roundabout. Motorists who could previously enter the flow of traffic at traffic lights with no problem, could find it almost impossible to get on the roundabout because of there being no gaps in the main stream. For this reason, investigations were also carried out at the selected roundabouts in the direction of the subsidiary flow and not just in the main flow direction.

1.1.6 Length of measurement distance

The measurement distances must be long enough for the effects of the crossing or roundabout (queue formation) on the stream of traffic throughout the measured trip to be included. They must not be too long, since the effects of the design of the node on traffic could then no longer be detected. If the measured distances are too long, it could also happen that the effect of a neighbouring pedestrian crossing or a junction could outweigh the effect of converting the crossing to a roundabout.

1.1.7 Measurement places with brief characteristics

Characteristic	Sihlbrugg	Emmen-brücke	Winterthur	Uttwil	Bülach
Traffic density (Max. hourly traffic over all branches)	Over 1,500 vehicles	Over 1500 vehicles	Less than 1,000 vehicles	1,000 to 1,200 vehicles	Over 1,500 vehicles
Position	out-of-town	in-town	in-town	in-town	in-town
Light signals	none	none	none	previously	none
Number of branches	3	4	4	4	4
External diameter of roundabout (m)	42	25/27 (Oval)	26	31	28
Lanes in the roundabout	2	1	1	1	1

1.2 Driving style

The planned measurements are for finding differences between trips over a crossing with or without traffic lights and trips around a roundabout.

The speed of travel is as shown in the speedometer, not the effective driven speed, the «normal» driver having to rely on the speedometer without knowing the exact speed.

Driving style is not crucial for this measurement project. It is sufficient if the style can be described as «defensive». «Defensive» is to correspond with the driving style practised by the majority of drivers.

Driving should be neither particularly economical nor especially urgent. When accelerating the revolutions should be between 2,500 and 3,000 rpm and at constant speed the gear to be engaged is that which allows smooth travel.

To investigate the effects of driving style, a second driver repeated some measuring trips. This driver was only used at the Emmenbrücke roundabout. The main driver (Driver 1) represents the defensive drivers, the second (Driver 2) the offensive drivers.

Travel was mainly at 50 km/h in third gear. Fourth gear was seldom engaged, e.g. on slight downward slopes or on quite level road travel. At 60 km/h (Sihlbrugg) driving was more in fourth gear. The offensive driver selected lower gears.

When stopped at red lights, the engine was not switched off, conforming to normal practice.

The main driver completed the overwhelming fraction of drives. The trips of the second driver, the offensive driver, were only to find out if the results of the first driver's trips depended on driving style or applied to the second driver too. The second driver did not travel all the routes under all the conditions, as the main driver did.

1.3 Measurement procedure

In a first phase, the measuring trips were carried out on the selected routes with the current traffic control (crossing). After conversion of the crossing to a roundabout, there was a pause before the measurement trips were started with the roundabouts. This waiting time after the conversion was to allow motorists to get used to the new traffic control. The before measurements were done between December 1998 and March 1999. The period for the after measurements was from December 1999 to March 2000.

1.4 Time of day for measurements

The measurements were carried out between 7.00 and 9.30, between 11.30 and 13.30 and between 16.00 and 18.00 hours. These times were defined so that travel in dense traffic (at rush hour) was included. When selecting days of the week, stress was laid on not measuring during holidays, bank holidays or other special days. Apart from that, all working days were regarded as equivalent.

1.5 Number of measurement trips

The number of measuring trips carried out per route and under defined conditions varied. Depending on the scatter of the measurement results, more or fewer trips were completed in a certain direction over the crossing or roundabout. A further criterion for the number of measuring trips per travel direction is whether significant differences are expected between the «before» and «after» situations. The effect on traffic joining by turning right, for example, is certainly less than on traffic joining by turning left. Where greater effects were expected, more measuring trips were made.

5 Results

Four typical directions of travel over the five different traffic nodes were selected as representative, from the huge number of possibilities. A characterisation and the summary of the results of the corresponding roundabouts complete the results for this travel route.

Emissions of hydrocarbons (HC) are too small to make detectable differences between trips over the crossing and round the roundabout. HC emissions are therefore ignored in the following sections. It should also be noted that emissions of oxides of nitrogen too are very small in absolute terms and therefore great percentage differences should be evaluated with a correct sense of proportion.

5.1 Sihlbrugg (Canton of Zug)

5.1.1 Characteristics of measurement routes

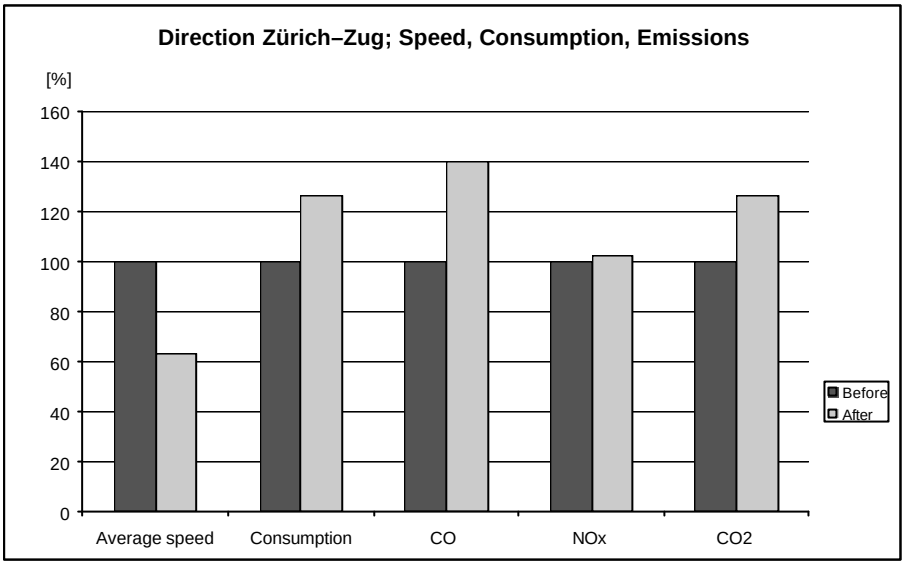
- High traffic density
- Complex crossing, chiefly consisting of three branches and further ways off to service stations and restaurants
- Without traffic lights
- Pedestrian crossing on the branch to Zug
- Two-lane access from Zug and Zürich, single lane from Hirzel
- Two-lane roundabout
- In the complex there is a collection of filling stations and restaurants
- Main road with right of way in the Zürich-Zug axis, with turn off to Hirzel and further ways off to filling stations and restaurants without precedence (crossing situation)
- No change of the indicated speed limits between the crossing and roundabout situations
- External diameter of the roundabout 42 m
- Length of measurement routes: 1.5 to 2 km

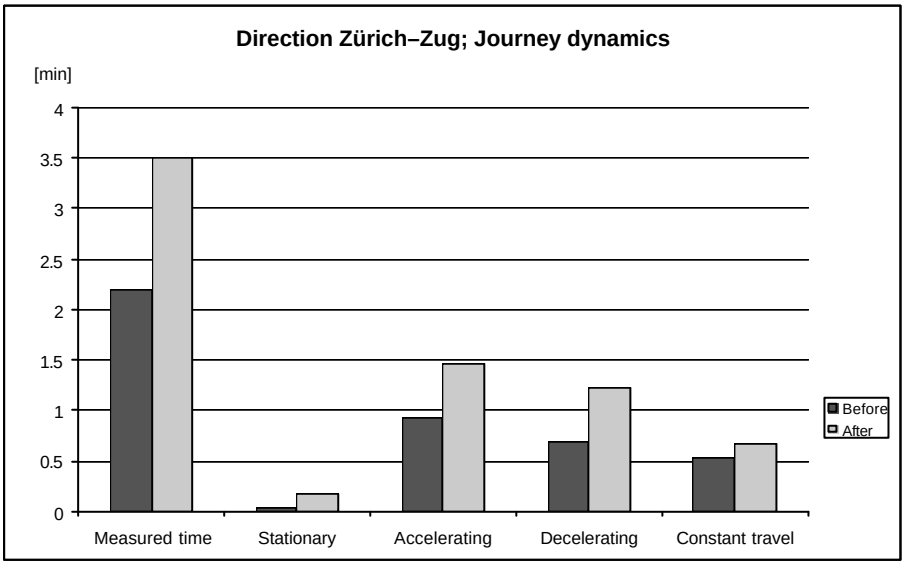
5.1.2 Overall result at Sihlbrugg roundabout

- The effects of the conversion from crossing to roundabout vary greatly from one direction to another. The roundabout leads to all branches having equal rights
- For the Zug–Zürich axis, this leads to a reduction in speed and to an interruption of the previously continuous travel with associated effects on emissions and fuel consumption.
- This applies to a lesser extent to the Zug-Hirzel direction. Here the average speed is lower and travel is less uniform because of the need to brake.
- The effects on the direction Hirzel–Zug are very good. The average speed with the roundabout is almost twice the previous speed over the crossing
- The few cars coming from Hirzel and then going towards Zürich are also able to get past with much less trouble.

5.1.3 Example 1: Direction Zürich–Zug

- Main axis of same importance as Zug–Hirzel
- In the direction of the traffic flow which had precedence before the conversion, the roundabout leads, as expected, to increasing the crossing time, consumption and CO and CO2 emissions.
- The proportion of time spent stationary increases.


Direction Zürich–Zug; Speed, Consumption, Emissions
[%]
160
140
120
100
80
60
40
20
0
Average speed
Consumption
CO
NOx
CO2
Before
After


Direction Zürich–Zug; Journey dynamics
[min]
4
3.5
3
2.5
2
1.5
1
0.5
0
Measured time
Stationary
Accelerating
Decelerating
Constant travel
Before
After

5.2 Emmenbrücke (Canton of Lucerne)

5.2.1 Characteristics of measurement routes

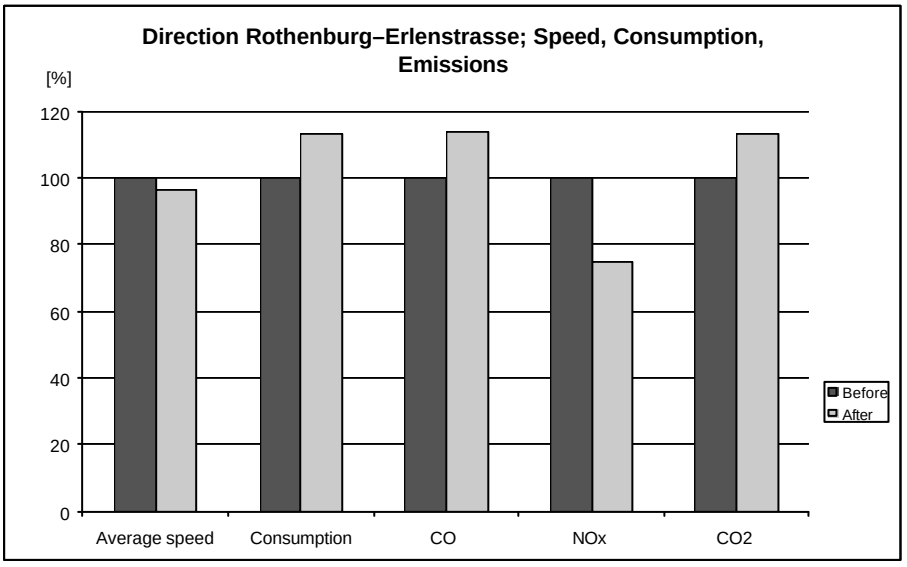
- Crossing Rothenburgstrasse/Schürstrasse, Benziwilstrasse; at the Restaurant St Christoph
- Crossing with 4 branches
- Main axis with two less important side branches
- Without traffic lights
- Single-lane access (with acceleration lane in the roundabout situation)
- Traffic lanes with pedestrian crossings
- In-town
- Main road with precedence (Rothenburgstrasse) with perpendicular junctions («No Precedence»)
- No change to the indicated speed limits between crossing and roundabout situations
- External diameter of roundabout 25/27 m (oval)
- Length of measurement routes: 0.3 to 0.5 km

5.2.2 Overall result Emmenbrücke roundabout

- The effects of this roundabout on fuel consumption and pollutants are variable.
- The effects on the main traffic axis are small.
- The courtesy of drivers, letting others enter or leave flow, leads to the advantages of the roundabout (easier entrance and exit) being less marked or undetectable.

5.2.3 Example 2: Direction Rothenburg–Erlenstrasse

- Main axis
- In the main direction of traffic flow, the results are small.
- The roundabout leads to an increase in consumption and CO and CO2 emissions.
- On the contrary, NOx emissions and proportion of constant travel decrease.
- In the main traffic direction, the roundabout leads to braking and then accelerating in the traffic which previously flowed at constant speed.
- The results did not come out more clearly in favour of the crossing since measurements were carried out in heavy traffic. In heavy traffic the cars move at an average speed of 35 km/h rather than the permitted 50 km/h.



5.3 Winterthur (Canton of Zürich)

5.3.1 Characteristics of measurement routes

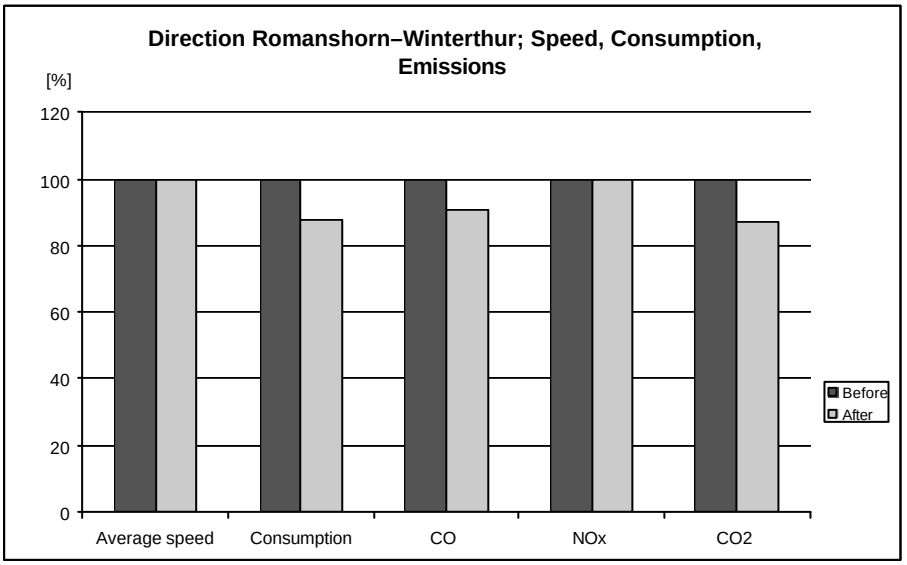
- Crossing Kanzleistrasse/Landvogt Waser Strasse
- Crossing with four branches
- Main axis with two less important side branches
- Without traffic lights
- Pedestrian crossings on all axes
- Single-lane access
- In-town
- Main road with precedence (Landvogt Waser Strasse) with perpendicular junctions («No Precedence»)
- No change of the indicated speed limits between the crossing and roundabout situations
- External diameter of the roundabout 26 m
- Length of measurement routes: 0.4 to 0.5 km

5.3.2 Overall result at Winterthur roundabout

- In almost all directions investigated, the roundabout led to a decrease in crossing times, fuel consumption and harmful emissions.
- At this roundabout, pedestrians have a great effect on traffic flow in the various directions via the roundabout.

5.3.3 Example 3: Direction Romanshorn–Winterthur

- Main axis with precedence
- Differences in the direction of the main traffic flow are small.
- The roundabout leads to a decrease in consumption and emissions of CO and CO2.
- No effect could be found on the low NOx emissions.
- In this direction there is a slight downward gradient on the measurement route. Emissions and fuel consumption are therefore lower than in the opposite direction



5.4 Uttwil (Canton of Thurgau)

5.4.1 Characteristics of measurement routes

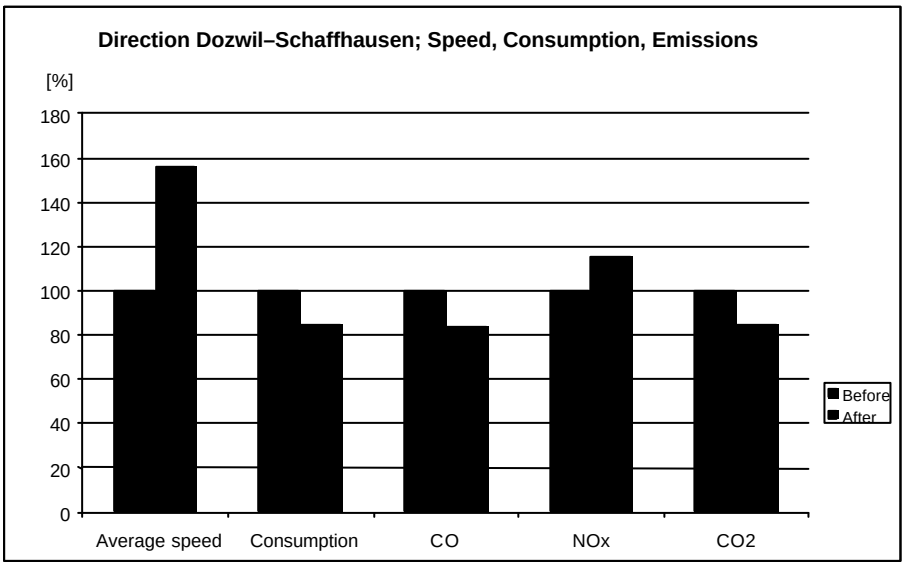
- Crossing with four branches
- Main axis with two less important side branches
- Traffic dependent traffic light control
- Pedestrian crossings on all the axes
- Single lane or two-lane access in the «crossing» situation, single lane access to the roundabout
- In-town
- No change of the indicated speed limits between the crossing and roundabout situations
- External diameter of the roundabout 31 m
- Length of measurement routes: 0.4 to 0.5 km

5.4.2 Overall result at Uttwil roundabout

- Conversion from a crossing with traffic light control into a roundabout has a very favourable effect on crossing times, fuel consumption and emissions of pollutants.
- In almost all directions investigated, the roundabout led to an improvement in crossing times, fuel consumption and pollutants.
- A disadvantage of a light controlled crossing is that it is often necessary to slow down or halt even when there is no other vehicle at the crossing. The better the lights are controlled, the lower the number of unnecessary halts.
- In measuring trips it can happen that the lights are at green more often than would be expected on average and therefore the advantages of the roundabout are less pronounced than they should be.

5.4.3 Example 4: Direction Dozwil–Schaffhausen

- Entry left into main axis from a side branch
- Traffic regulated at the crossing by lights
- The roundabout leads to a decrease in travel time, consumption and emissions of CO and CO2.
- The very low NOx emissions increase.
- Stationary time decreases to zero. Travel can be without halts.
- Compared with the traffic-controlled lights, which nevertheless sometimes force stopping, the roundabout has very favourable results.



6 Overall results

- The consequences for crossing times, fuel consumption, emissions of pollutants etc. of converting a crossing into a roundabout, are very dependent on local factors such as amount of traffic, numbers of pedestrians, the ratio of traffic densities on the different branches etc. Individual pedestrians can interfere greatly with traffic flow.
- These effects can also be different at different times of day, being dependent on traffic density. There can be an unfavourable effect during rush hour times with favourable effects in between.
- There are favourable results when a crossing with traffic-controlled lights is replaced by a roundabout. The advantages are even greater when the traffic lights are time-controlled.
- The effects of a roundabout on consumption and emissions of pollutants are often unfavourable because of a previously uniform traffic flow being disturbed by the roundabout. Slowing down and acceleration which the roundabout forces (and are advantageous to traffic safety) lead to higher consumption and higher harmful emissions.
- If a roundabout replaces what is often the standard situation, the «straight main axis with two or three side branches», that leads to higher consumption and emissions of pollutants for the above reasons. If there are gradients to be overcome, this effect can be even greater.
- In traffic situations with a main axis and two or more side axes, the effects on crossing time, fuel consumption and emissions of pollutants are often unfavourable on the main axis but favourable on the side axes. The overall view can turn out favourable or unfavourable depending on amount of traffic and other parameters.
- If the traffic flow on the side branches is significantly lower (by a factor of 5 to 10), unfavourable effects are more to be expected from the roundabout.
- If a roundabout replaces a four road crossing without lights with a main axis, the differences between crossing and roundabout are very dependent on the courtesy of motorists. The differences are small if motorists with right of way allow others to join or turn off.
- Two-lane roundabouts with an external diameter of about 40 m do not lead to greater traffic flow since motorists are reluctant to change to the inner lane.
- The replacement of a crossing by a roundabout may have some effect on the local immission situation. No regional effects could be found.
- There are no general statements to be made on the effect of replacing a crossing with a roundabout. In an individual case, the most nearly similar roundabout must be sought from those given above. The tendencies of the results there are transferable depending on similarity.

7 Acknowledgement

The research station would like to thank the Federal Ministry for Roads for their support in carrying out this research project. Also included in the thanks are members of the Accompanying Commission who have helped to design the investigations by their active co-operation.

8 Index of literature and sources

This index of literature and sources refers to the much more detailed original report (100 pages), available from TCS Emmen (Peter Züger: ++41/41/267 18 35 or pzueger@tcs.ch).

[1] **Schadstoffemissionen bei verschiedenen Geschwindigkeiten, Teilbericht Etappe 1: 30/50 km/h**; Forschungsauftrag 63/92 auf Antrag des ASB; Touring Club Schweiz; P. Züger, D. Burch, P. Riedwyl, A. Porchet; Bern, September 1995

[2] **Schadstoffemissionen bei verschiedenen Geschwindigkeiten, Teilbericht Etappe 2: 100/120 km/h**; Forschungsauftrag 63/92 auf Antrag des ASB; Touring Club Schweiz; P. Züger, D. Burch, A. Porchet, P. Riedwyl; Bern, November 1996

[3] **Die Mobile AbgasMessAnlage – Ein Vergleich mit dem Schweizer Personenwagenpark**; Touring Club Schweiz; P. Züger; Emmen, Januar 1998

[4] **Schweizer Norm SN 641 140: Massgebender Verkehr**; Vereinigung Schweizerischer Strassenfachleute (VSS); Zürich, Mai 1970

[5] **Schweizer Norm SN 641 230a: Ganglinien und durchschnittlicher täglicher Verkehr**; Vereinigung Schweizerischer Strassenfachleute (VSS); Zürich, Mai 1990
[6] **Bundesbeiträge gestützt auf die Luftreinhalteverordnung**; J. Koch; strasse und verkehr, Nr. 11, November 1995 (enthält Zitat aus «Minirondellers effekter pa hastighet, tidsförbrukning, bensinförbrukning och avgasutsläpp»; Studie von Andras Varhelyi an der University of Lund, Schweden)
[7] **Unfallgeschehen und Geometrie der Kreiselanlagen**; Forschungsauftrag 17/93 auf Antrag der Vereinigung Schweizerischer Strassenfachleute (VSS); Nr. 382; F. Bühlmann, P. Spacek; Zürich, März 1997
[8] **Wege der Schweizer, Ergebnisse des Mikrozensus zum Verkehrsverhalten 1994;** GVF-Bericht 2/96; Bern, Mai 1996
[9] **Einfluss eines Kreisels auf die Luftbelastung in Strassennähe**; P. Künzler, G. Nejedly; strasse und verkehr, Nr. 1, Januar 1997
[10] **Verkehrsbeeinflussung an Kreiseln, erste Erfahrungen**; SNZ-Notizen Nr. 451; SNZ Ingenieurbüro AG, Dörflistr. 112, 8050 Zürich
[11] **Der Kreisverkehr**; TCS; Gland, Februar 1994
[12] **Berechnung der Emission im Kreiselverkehr General-Guisan-Platz, Biel**; Ingenieurschule Biel, Abgasprüfstelle, 2560 Nidau; J. Czerwinski, Th. Mosimann, Ph. Wili; Bundesamt für Strassenbau; April 1996
[13] **Kreisverkehr senkt Unfallgefahr und Lärm**; ADAC; Nachrichten der ADAC-Pressestelle; 3. August 1995
[14] **Les giratoires en Suisse: on ne les compte plus!**; publication «strasse und verkehr; route et traffic», Nr. 11/95; P. Bovy, N. Henderson; Institut des transports et de planification, EPFL
[15] **Kreisverkehrstechnik, die Bieler Versuche**; R. Leisi; Leisi + Partner, Biel; strasse und verkehr, Nr. 9, September 1996
[16] **Kreisel**; strasse und verkehr, Nr. 3, 1991
[17] **Kreisel**; strasse und verkehr, Nr. 11, 1995
[18] **Langsamer und flüssiger fahren, Niedriggeschwindigkeitsszenarien und ihre Wirkungen**; Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung, Abteilung nationale Forschungsprogramme; W. Hüsler, R. Häfliger, I. Schmid, E. Willi; Zürich, 1994
[19] **Umweltrelevanz von Verkehrsmassnahmen, Untersuchung der Umweltauswirkungen von Knotenumgestaltungen in Heimberg**; Balzari und Schudel AG; Koordinationsstelle für Umweltschutz des Kantons Bern; Bern, 28. Februar 1993
[20] **Guide suisse des giratoires; Fonds für Verkehrssicherheit**; H. Bovy, K. Dietrich, A. Harmann; Lausanne, Februar 1991
[21] **Carrefours giratoires**; Ecole Polytechnique Fédérale de Lausanne, département de génie civil; P. de Aragao; Lausanne, September 1988
[22] **Die Kreisel im kantonalen Strassennetz, Verwirklichungen seit 10 Jahren 1985 - 1995**; Strassen- und Brückendepartement, Freiburg, Oktober 1995
[23] **Sicherheit von Kreiselanlagen, Erfahrungen und vorläufige Empfehlungen, Pilotstudie**; C. A. Huber, F. Bühlmann; Bern, Dezember 1994
[24] **Unfallgeschehen und Geometrie der Kreiselanlagen**; Forschungsauftrag 17/93 auf Antrag der Vereinigung Schweizerischer Strassenfachleute (VSS); Nr. 382; F. Bühlmann, P. Spacek; Zürich, März 1997
[25] **Empfehlungen zum Einsatz und zur Gestaltung kleiner Kreisverkehrsplätze**; Freistaat Sachsen; Staatsministerium für Wirtschaft und Arbeit; Dresden, Januar 1994
[26] **Accidents at roundabouts in Kent: Kent County Council**; Highway & Transportation; Januar 1994
[27] **Sicherheit von Verkehrskreiseln; Informationstagung vom 12. Oktober 1993**; Aus der Sicht des motorisierten Benutzers; Schweizerischer Verkehrssicherheitsrat; Bern, November 1993
[28] **Integrales Simulationsmodell für Kreisverkehr, LogSim**; Leisi + Partner; Biel, 1996
[29] **Grundlagen zur Beurteilung von Kreiseln bei Autobahnanschlüssen**; Auszug aus «Kreisel bei Autobahnanschlüssen im Kanton Freiburg»; IVT, bfu, Ingenieur- und Planungsbüro Bühlmann, Zollikon; Freiburg, Dezember 1994

[30] **Nachführung der Emissionsgrundlagen Strassenverkehr**; EMPA, Abteilung Verbrennungsmotoren/Feuerungen; T. Schweizer; Dübendorf, April 1998
[31] **Schweizer Norm SN 640 251: Knoten**; Vereinigung Schweizerischer Strassenfachleute (VSS); Zürich, Oktober 1997
[32] **Schweizer Norm SN 640 263; Knoten, Knoten mit Kreisverkehr**; Vereinigung Schweizerischer Strassenfachleute (VSS); Zürich, Dezember 1999
[33] **Verkehrsanlage Sihlbrugg**; Baudirektion des Kantons Zug; Baar, 1999