Safety evaluation of Czech roundabouts

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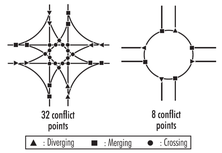
INTRODUCTION

Intersections are critical elements of the road network and complex traffic situations (*1*).
In most countries between 40 and 60% of total crashes occur at intersections (*2*).

In this context roundabouts are often seen as a beneficial measure for intersection safety due to (*3*):
– elimination of conflict points (*4*)
– speed reduction due to yielding and changing trajectory

Several studies demonstrated roundabout conversion benefits in terms of before-after crash frequency reductions. For example meta-analysis of non-US studies (*5*) showed:
– 30% to 50% reduction of injury crashes
– 50% to 70% reduction of fatal crashes



Czech roundabouts are typically unsignalized, located on urban roads, 4 legs, single lane (*6*). Their typical diameter is 30 – 40 m, lane width 6 – 7 m, average traffic volume 12,000 vpd.



In recent decade their numbers have grown up to current number over 1,200. Nevertheless their safety impact has not been fully studied still. At the same time Czech roundabouts have been sometimes seen as unpopular, including doubts about their benefits, even from the Minister of Transport or Czech Police representatives.

This controversy and lack of solid knowledge inspired the authors to investigate three general research questions related to Czech roundabouts:

Are roundabouts safer than traditional intersections?

Are roundabout conversions beneficial for safety?

Is Czech roundabout safety performance comparable to other countries?

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REFERENCES

1. Ogden, K. W. *Safer Roads: Guide to Road Safety*. Ashgate, 1997.
2. *Roads*. European Road Safety Observatory, 2006.
3. Elvik, R. *et al. The Handbook of Road Safety Measures, Second Edition*. Emerald, 2009.
4. *Road Safety Manual: Recommendations from the World Road Association*. Route2market, 2003.
5. Elvik, R. Effects on Road Safety of Converting Intersections to Roundabouts: Review of Evidence from Non-U.S. Studies. *TRR*, 1847, 1-10.
6. Novák, J., and J. Ambros. Rozšíření predikčního modelu nehodovosti na okružních křižovatkách. In *20. Silniční konference*, 2012.
7. Gross, F. *et al. A Guide to Developing Quality Crash Modification Factors*. FHWA, 2010.
8. Hauer, E. *Observational Before-After Studies in Road Safety: Estimating Effect of Highway and Traffic Engineering Measures on Road Safety.* Pergamon Press, 1997.
9. Srinivasan, R. *et al.* Safety Effectiveness of Selected Treatments at Urban Signalized Intersections. *TRR*, 2056, 70-76.
10. Hauer, E. On exposure and accident rate. *TEC*, 1995, 134-138.
11. Ambros, J., and P. Slabý. Comparison of Roundabout Accident Prediction Models. In *20th Anniversary of the Faculty of Transportation Sciences*, 2013.

ARE ROUNDABOUTS SAFER THAN TRADITIONAL INTERSECTIONS?

Data and method

– Two groups: traditional intersections and roundabouts
– Data sources: crash information and road network information

Crash information

– Routinely collected by Czech traffic police
– 4 severity levels: property-damage-only (PDO), slight/severe/fatal injury
– Numbers and distributions published in annual reviews
– Changes in PDO crash reporting thresholds (the last one in 2009) make time series incompatible

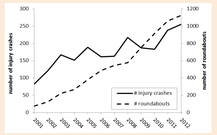
Road network information

– Administered by Czech Road and Motorway Directorate (RSD)
– Since 2001 available in GIS form
– Does not cover local roads, thus neither intersections with these roads

Comparison

In order to avoid the incompatibility in PDO crash numbers, only injury crashes have been considered.

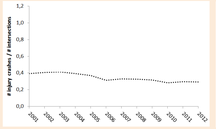
1) *Absolute comparison*
– number of injury crashes
– number of intersections

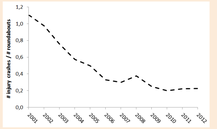


traditional intersections roundabouts

2) *Relative comparison*

$$ratio = \frac{\#injury\,crashes}{\#intersections}$$





Ratio has been: – *stable* for traditional intersections
– *declining* for roundabouts

In recent years (2009-2012) there were approx. 0.3 injury crashes per traditional intersection, while roundabouts yielded 0.2 injury crashes, indicating them as **safer intersection design**.

In addition **safety at roundabouts has been gradually improving**, while it has not changed at traditional intersections.

YES. Roundabouts are safer than traditional intersections.
Their safety has also been gradually improving in recent years.

ARE ROUNDABOUT CONVERSIONS BENEFICIAL FOR SAFETY?

Method

Crash modification factor (CMF) links crash frequencies before and after treatment = roundabout conversion (*7*):

(# crashes after conversion) = ***CMF*** *x (# crashes before conversion)*

CMF > 1.0 ... increase in crashes
CMF < 1.0 ... reduction in crashes

Before-after methodology with empirical Bayes correction ("EB approach") is the recommended approach for estimating CMF. The method corrects for regression to the mean and other confounding factors. (*8*)

The change in safety for a site is given by (*9*):

B – **A**

crashes that *would have occurred* after conversion — # crashes that *occurred* after conversion

expected crashes — *reported* crashes
reference group — **treatment group**

In estimating B, the effects of confounding factors are explicitly accounted for by estimating safety performance functions (SPF). The individual values of B are summed over all sites in a group of roundabout conversions (B_{sum}) and compared with the count of crashes during the after period in that group (A_{sum}). The variances are also computed and summed over all sites in the group of conversions.

$$CMF = \left(\frac{A_{sum}}{B_{sum}}\right) / \left(1 + \frac{varB_{sum}}{B^2_{sum}}\right)$$

$$\%change = 100 \cdot (1 - CMF)$$

Data

Treatment group: conversion to Czech typical roundabout (urban roads, unsignalized, 4 legs, single lane) ... 18 cases

Reference group: intersections of the same design as the treatment group, but not converted ... 66 cases

Crash frequencies and traffic volume (sum of entering vehicles) were assigned to both groups.

SPF: $crashes / year = alpha \cdot traffic^{beta}$

Results

– *Total crashes:* crash reduction **52%** (confidence interval 37% – 67%)
– *Injury crashes:* crash reduction **53%** (confidence interval 37% – 68%)

The results are positive and significant (the confidence intervals do not include zero).
They are also consistent with international studies.

YES. Roundabout conversions are beneficial for safety.
It has been confirmed by before-after study which yielded positive crash modification factors.

IS CZECH ROUNDABOUT SAFETY PERFORMANCE COMPARABLE TO OTHER COUNTRIES?

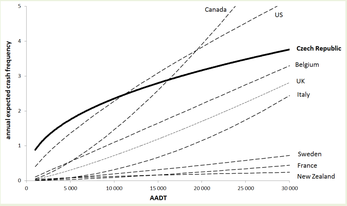
Data and method

Illustrative international comparison was made, using simple safety performance functions (*10*) (SPFs), which relate safety performance (annual crash frequency) to exposure (annual average daily traffic volume, AADT).

Only 4-leg single lane roundabouts, as a typical Czech roundabout design type, were selected
In total 196 roundabouts were used for Czech SPF (*11*).

The Czech SPF was compared with several other models used in the world that were retrieved from the literature. They included some European examples (Belgium, France, Italy, Sweden, UK) as well as US, Canada and New Zealand.

Results



The curves indicate that:
– traditionally safe countries (Sweden, New Zealand) have the lowest expected crash frequencies
– North America (US and Canada) has similar shapes on the other side of the range
– most European countries (Belgium, UK, Italy) have values between those two thresholds

Compared to North American SPFs Czech crash frequencies are higher at below-average AADT and lower at above-average AADT. In addition compared to other European countries (and New Zealand) Czech SPF performs worse in the whole range of AADT values.

However there may be several other reasons to the differences between SPFs, for example:

– *Various crash reporting practices.* Most countries report just injury crashes, while Czech SPF utilized also PDO crashes. There are differences with crash reporting among specific countries as well: for example in Sweden and New Zealand only approx. 40% of injury crashes are reported, while in the US (and also in the Czech Republic) it is 70% and even 100% in Italy.

– *Definition of intersection crashes.* There is no uniform criterion used for assigning a crash to an intersection. For example Belgian (and also Czech) practice is to consider all crashes within an area of 100 m, while in Canada 20 m limit is used, 30 m in Sweden and 50 m in New Zealand.

– *Design and traffic differences.* For example roundabouts in France have a long tradition, and hey were built there primarily for safety reasons. On the contrary, the US and UK use roundabouts mainly because of capacity. These underlying concepts dictate for example the choice of diameter size. There are also international differences in the age of roundabouts, data coverage of rural/urban areas, speed characteristics, climate conditions, etc.

NO. Czech roundabout safety performance is not comparable to other countries. Czech expected crash frequencies are higher compared to other European countries.

CONCLUSIONS:
Safety level of roundabouts may be deemed sufficient in the Czech context: they are generally safer than traditional intersections. There is no reason to limit the increasing trend of roundabout constructions.
However Czech roundabout safety performance runs behind other countries. Generally Czech traffic is not sufficiently safe in European context. One of improvements may be increasing safety of Czech roundabouts.