APPLICATION OF CRASH PREDICTION MODELS FOR ROUNDABOUTS IN THE CITY OF ZAGREB

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ABSTRACT

For the past decade the common construction of roundabouts in Croatia resulted in multiple benefits, of which the most important are traffic safety and capacity. Encouraged by the use and construction practices of the neighbouring countries, the designers and scientists have neglected their own studies in actual situations and environment. In order to bring the design elements of roundabouts to optimum traffic safety and capacity, crash prediction models are widely used in the United Kingdom and New Zealand. This paper presents two crash prediction methods which are used in the United Kingdom and New Zealand. These two methods will be applied and analyzed on the roundabouts located in the urban and suburban areas of the City of Zagreb. The research results should be used, among other things, for the selection method that would be used for crash prediction on roundabouts in Croatia.

Keywords: roundabout, crash prediction model, traffic safety and capacity

1 INTRODUCTION

Intersections with circular traffic flow have become an increasingly applicable form of intersection on the roads of the European countries. The popularity of constructing these forms of intersection versus classical intersections is reflected in higher throughput capacity and intersection safety level. On the contrary, the consequence of non-professional design and construction of intersections with circular traffic flows lies in the low level of capacity and traffic safety. The past attempts at improving the traffic safety level at roundabouts have resulted usually in the reduction of the level of intersection safety and capacity. The reason lies in the insufficient knowledge of the designers regarding proper design elements, capacity and safety of the roundabouts. For the forecasting of the number of traffic accidents at the roundabouts various models have been developed and verified. However, no proper model has been developed for the Republic of Croatia, nor is any of the existing ones being applied. The goal of the paper is by applying two foreign methods for traffic accident forecasting to the roundabouts of the City of Zagreb to create the bases for selecting a method that would be applicative in crash prediction at roundabouts both in the City of Zagreb and on the territory of the Republic of Croatia.

2 CRASH PREDICTION METHODS

2.1 Crash prediction methods according to Maycock and Hall (1984)

By applying the exponential linear modelling taking the variables of the traffic flow and roundabout geometries, and describing the characteristics and knowledge from 84 roundabouts in England, Maycock and Hall (1984) have developed a crash prediction model at the intersections with circular traffic flow for five types of traffic accidents.

The traffic accident types that the authors used to develop the prediction model include:

- entering vs circulating (motor vehicle only),
- approaching,
- single vehicle,
- other (vehicle),
- pedestrian.

The model expression is presented further in the text, where *A* – is the number of accidents through the year per approach, *Q* – the roundabout capacity per day (*Qc* – capacity in the roundabout), *Gi* - geometrical and other variables, whereas α, β, b_i and *k* - coefficients and estimates [1].

$$A = kQ^{\alpha} (Q_C^{\beta}) \exp \sum (b_i G_i) \tag{1}$$

For every type of traffic accidents the following expressions have been developed:

1. Entering vs circulating (motor vehicle only)

$$A = 0{,}052Qe^{0{,}7} * Qc^{0{,}4} * \exp(-40Ce + 0{,}14e - 0{,}007ev - \frac{1}{1 + \exp(4R - 7)} + 0{,}2Pm - 0.01Q) \tag{2}$$

where:

A = personal injury crashes (including fatalities) [injury/year]
Q_e = entering flow [vehicles/day]
Q_c = circulating flow [vehicles/day]
C_e = entry curvature = $1/R_e$ [m^{-1}]
e = entry width [m]
v = approach width [m]
R = ratio of inscribed circle diameter/central island diameter
P_m = proportion of motorcycles [%]
q = angle to next leg, measured centerline to centerline [◦]

2. Approaching

$$A = 0{,}0057Qe^{1{,}7} * \exp(20Ce - 0.1e) \tag{3}$$

where:

A = personal injury crashes (including fatalities) [injury/year]
Q_e = entering flow [vehicles/day]
C_e = entry curvature = $1/R_e$ [m^{-1}]
R_e = entry path radius for the shortest vehicle path [m]
e = entry width [m]

3. Single vehicle

$$A = 0{,}0064Qe^{0,8} * \exp(25Ce + 0.2v - 45Ca) \tag{4}$$

where:
A = personal injury crashes (including fatalities) [injury/year]
Q_e = entering flow [vehicles/day]
C_e = entry curvature = 1/Re [m^{-1}]
R_e = entry path radius for the shortest vehicle path [m]
V = approach width [m]
C_a = approach curvature = 1/Ra [m^{-1}]
R_a = approach radius [m] defined as the radius of a curve between 50 m

4. Other (vehicle)

$$A = 0{,}0064Qe^{0,8} * \exp(25Ce + 0.2v - 45Ca) \tag{5}$$

where:
A = personal injury crashes (including fatalities) [injury/year]
Q_{ec} = product Qe* Qc
Q_e = entering flow [vehicles/day]
Q_c = circulating flow [vehicles/day]
P_m = proportion of motorcycles [%]

5. Pedestrian

$$A = 0{,}029Qep^{0,5} \tag{6}$$

where:
A = personal injury crashes (including fatalities) [injury/year]
Q_{ep} = product (Qe + Qex)*Qp
Q_e = entering flow [vehicles/day]
Q_{ex} = exiting flow [vehicles/day]
Q_p = pedestrian crossing flow [pedestrians/day]

Furthermore, the research results have resulted in the knowledge about the influencing parameters that significantly affect the traffic accidents, such as: entry path radius [m], entry width [m], approach width [m], ratio of inscribed circle diameter/central island diameter, proportion of motorcycles [%], [1].

Figure 1 shows the relation between the number of accidents over the year per approach and the entry curvature for individual types of traffic accident.

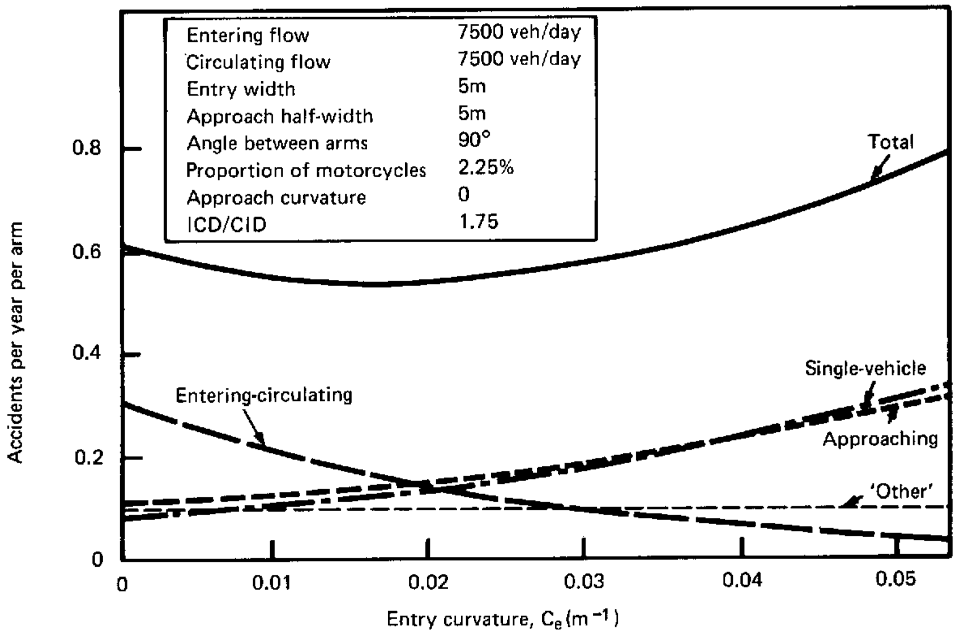

Figure 1: Relation between the number of accidents over the year per approach and entry curvatures [2]

2.2 Crash prediction method according to turner (2006)

The method is based on the parameters of the traffic flow, visibility, vehicle speed and the number of traffic lanes on the approach and on the circular roadway, and it is used for six types of traffic accidents. The expression of the model is presented below, where A – the number of accidents through the year [crashes/year], q_1 – entry capacity (q_2 – capacity in the circular flow), whereas b_0, b_1, b_2 are parameter values

$$A = b_0 q_1^{b1} (q_2^{b2}) \tag{7}$$

The traffic accident types that Turner included in the prediction model development include:

- entering vs circulating (motor vehicle only)
- rear-end (motor vehicle only)
- loss of control (motor vehicle only)
- other (motor vehicle only)
- pedestrian
- entering vs circulating cyclist.

For every type of the traffic accident the following expressions have been developed:

1. Entering vs circulating (motor vehicle only)

$$A = 6{,}12 * 10^{-8} * Q_e^{0{,}47} * Q_c^{0{,}26} * S_c^{2{,}3} \tag{8}$$

where:

A = annual number of entering versus circulating crashes involving motor vehicles only [crashes/year]

Q_e = entering flow on the approach [vehicles/day]

Q_c = circulating flow perpendicular to the entering flow [vehicles/day]

S_c = free mean speed of circulating vehicles as they pass the approach being modelled [km/h]

2. Rear-end (motor vehicle only)

$$A = 9{,}63 * 10^{-2} * Q_e^{-0{,}38} * e^{0.00024Qe} \quad (9)$$

where:
A = annual number of rear-end entering crashes involving motor vehicles only [crashes/year]
Q_e = entering flow on the approach [vehicles/day]

3. Loss of control (motor vehicle only)

$$A = 6{,}36 * 10^{-6} * Q_a^{0{,}59} * V_{10}^{0{,}68} \quad (10)$$

where:
A = annual number of rear-end entering crashes involving motor vehicles only [crashes/year]
Q_a = approach flow (sum of entering and exiting flows)
V_{10} = visibility 10m back from the limit line to vehicles turning right or travelling through the roundabout from the approach to the right [m]
Q_{ex} = exiting flows [veh/day]
Q_e = entering flow on the approach [vehicles/day]

4. Other (motor vehicle only)

$$A = 1{,}34 * 10^{-5} * Q_a^{0{,}71} * \Phi_{MEL} \quad (11)$$

where:
A = annual number of 'other' crashes involving motor vehicles only [crashes/year]
Q_{ex} = exiting flows [veh/day]
Q_e = entering flow on the approach [vehicles/day]
Q_a = approach flow (sum of entering and exiting flows)
Φ_{MEL} = factor to multiply the crash prediction by if multiple entry lanes are present.

This factor is Φ_{MEL}=2.66

5. Pedestrian

$$A = 3{,}45 * 10^{-4} * P^{0{,}60} * e^{0{,}000067Qa} \quad (12)$$

where:
A = annual number of pedestrian crashes, [crashes/year]
Q_a = approach flow (sum of entering and exiting flows)
Qex = exiting flows [vehicles/day]
Q_e = entering flow on the approach [vehicles/day]
P = pedestrians crossing the approach in either direction

6. Entering vs circulating cyclist

$$A = 3{,}88 * 10^{-5} * Qe^{0{,}43} * Cc^{0{,}38} * S_{LL}^{0{,}49} \quad (13)$$

where:

A = annual number of entering vs circulating cyclist crashes [crashes/year]

Q_e = entering flow on the approach [vehicles/day]

C_c = circulating cyclist flow perpendicular to the entering motor vehicle flow [cyclist/day]

S_{LL} = free mean speed of vehicles as they enter the roundabout.

According to Turner the traffic and other variables that significantly affect the traffic accidents at roundabouts include: capacity in the roundabout [vehicles/day], capacity at the entry [vehicles/day], flow of pedestrians [pedestrians/day], flow of cyclists [cyclist/day], vehicle speed on entering the circular roadway [km/h], visibility from the entry into the circular roadway [m].

Table 1 contains recommended statistical values of the model for individual types of traffic accidents according to Turner. The values lower than 0.05 and greater than 1 indicate a bad model regarding the deficiencies of the gathered data, whereas high values from 0.05 to 1 indicate very good fitting and applicability of the model with the data.

Table 1: Recommended value of statistical models [4]

Accident Type	Equation(accident per approach)	Error Structure	GOF
Entering-vs-Circulating (motor vehicle)	$A = 6.12*10^{-8}*Q_e^{0.47}*Qc^{0.26}*Sc^{2.13}$	NB (k=1.3)	0.26
Rear-end (motor vehicle)	$A = 9.63*10^{-2}*Q_e^{-0.38}*e^{2.42Qe}$	NB (k=0.7)	0.25
Loss-of-control (motor vehicle)	$A = 6.36*10^{-6}*Q_a^{0.59}*V_{10}^{0.68}$	NB (k=3.9)	0.25
Other (motor vehicle)	$A = 1{,}34*10^{-5}*Q_a^{0{,}71}*\Phi_{MEL}$ $(\Phi_{MEL}=2.66)$	Poisson	0.17
Pedestrian (motor vehicle)	$A = 3.45*10^{-4}*P^{0.60}*e^{2.42Qa}$	NB (k=1.0)	0.17
Entering-vs-Circulating (cyclist)	$A = 3.88*10^{-5}*Qe^{0.43}*Cc^{0.38}*S_{LL}^{0.49}$	NB (K=1.2)	0.61

Contents: *k is the gamma distribution shape parameter for the negative binomial (NB) distribution.
**GOF (Goodness Of Fit statistic) indicates the fit of the model to the data. A value of less than 0.05 indicates a poor fit whereas a high value (above 0.5) indicates a very good fit.

3 ANALYSIS OF ROUNDABOUT SAFETY IN THE CITY OF ZAGREB

Certain studies of the roundabout safety components in the Republic of Croatia started to be monitored only over the last few years, and organized and consistent studies started with the scientific-research project “Correlation of the Designability and Safety in Intersections with Circular Traffic Flow” (MZOŠ-FPZ, 2008-2012), [5]. Further in the text the preliminary results of the field research of roundabouts in the City of Zagreb are presented.

The safety analysis results are presented at three standard roundabouts in the city of Zagreb. The diagram of collisions in the intersection has been developed in agreement with MUP (Ministry of the Interior), as well as the processing and the analysis of the statistical data (Figure 2).

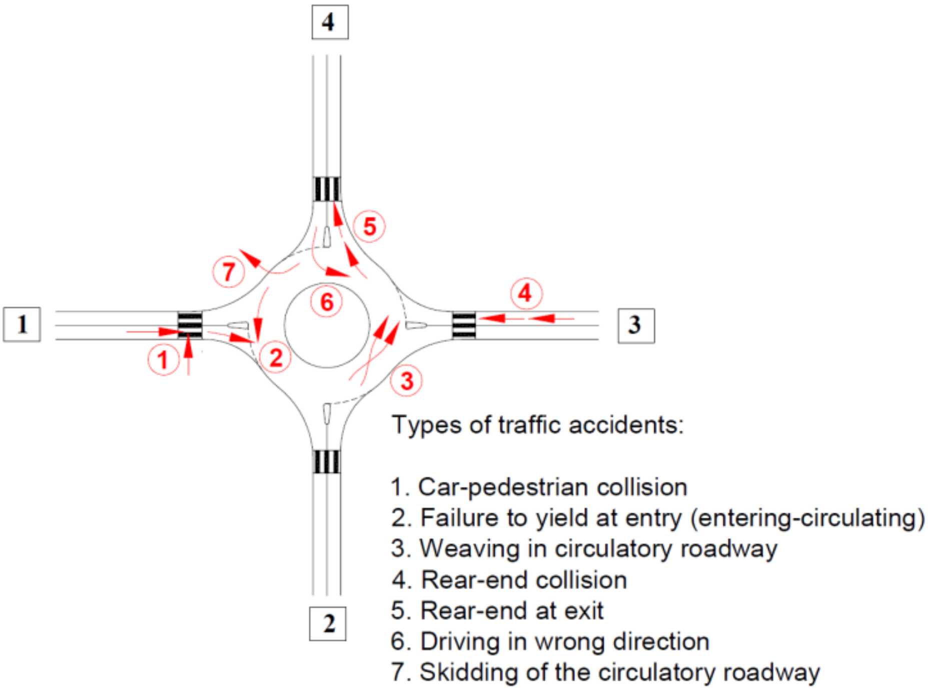

Figure 2: Diagram of collisions in the roundabout [6]

The types of traffic accidents are divided into: 1 – collision with pedestrian/cyclist, 2 – crash at entry, 3 – crash in interweaving, 4 – rear-end collision, 5 – collision at exit, 6 – driving in wrong direction, 7 – skidding off the circulatory roadway, whereas the consequences of the traffic accidents are divided into: 1 – fatalities, 2 – injured.

The data on the number and type of traffic accidents have been collected by MUP for the time period from 2006 to 2008, and for the time period between 2008 and 2011 the data were collected from the insurance agencies (Hok insurance d.d and Velebit insurance d.d). The types and the number of traffic accidents at the three standard roundabouts in the time period from 2006 to 2011 are presented in the following graphs and tables.

a) Roundabout: Street Sveti Duh – Street Kuniščak;

	INSURANCE			MUP		
	Year					
Types of accident	2011	2010	2009	2008	2007	2006
1. Car-pedestrian	0	1	0	0	1	1
2. Failure to yield at entry	0	3	0	1	1	0
3. Weaving in circulatory roadway	1	1	2	1	0	0
4. Rear-end collision	2	0	1	0	0	0
5. Rear-end at exit	0	2	0	0	0	0
6. Driving in wrong direction	0	0	0	0	0	0
7. Skidding of circulatory roadway	0	0	0	1	1	4
∑	3	7	3	3	3	5
Accident Frequency [Acc/Yr]	0,008	0,019	0,008	0,008	0,01	0,01
Consequences of accidents						
1. Fatal injuries	0	0	0	0	0	0
2. Injured	2	1	0	0	1	0
∑	2	1	0	0	1	0
Accident Frequency [Acc/Yr]	0,005	0,003	0	0	0,003	0

Contents: INSURANCE-Insurance companies (HOK,VELEBIT), MUP-Croatian Ministry of Interior

b) Roundabout: Petrova Street – Street Jordanovac;

	INSURANCE			MUP		
	Year					
Types of accident	2011	2010	2009	2008	2007	2006
1. Car-pedestrian	1	0	1	0	1	0
2. Failure to yield at entry	0	1	0	0	0	1
3. Weaving in circulatory roadway	0	1	0	0	0	0
4. Rear-end collision	2	1	2	0	0	0
5. Rear-end at exit	2	1	3	0	0	0
6. Driving in wrong direction	0	0	0	0	0	0
7. Skidding of circulatory roadway	0	1	0	0	0	0
∑	5	5	6	0	1	1
Accident Frequency [Acc/Yr]	0,014	0,014	0,016	0	0	0
Consequences of accidents						
1. Fatal injuries	0	0	0	0	0	0
2. Injured	1	0	1	0	1	0
∑	1	0	1	0	0	0
Accident Frequency [Acc/Yr]	0,003	0	0,003	0	0,003	0

Contents: INSURANCE-Insurance- companies (HOK,VELEBIT), MUP-Croatian Ministry of Interior

c) Roundabout Voćarska Street – Bijenička Street

	INSURANCE			MUP		
	Year					
Types of accident	2011	2010	2009	2008	2007	2006
1. Car- pedestrian	1	0	1	0	1	0
2. Failure to yield at entry	1	0	0	0	0	1
3. Weaving in circulatory roadway	1	0	1	0	0	0
4. Rear-end collision	2	0	3	0	0	0
5. Rear-end at exit	2	2	1	0	0	0
6. Driving in wrong direction	0	0	0	0	0	0
7. Skidding of circulatory roadway	0	0	1	0	0	0
∑	7	2	7	0	1	1
Accident Frequency [Acc/Yr]	0,019	0,005	0,019	0	0,003	0,003
Consequences of accidents						
1. Fatal injuries	0	0	0	0	0	0
2. Injured	1	0	1	0	1	0
∑	1	0	1	0	1	0
Accident Frequency [Acc/Yr]	0,003	0	0,003	0	0,003	0

Contents: INSURANCE-Insurance companies (HOK,VELEBIT), MUP-Croatian Ministry of Interior

Graph 1: Observed roundabouts with the number, type and frequency of accidents

The traffic data of the studied intersections are presented in Table 2, whereas Table 3 shows the design elements, visibility and the vehicle speed. For the needs of analysis the last measurable data about the motor and non-motor traffic were used, obtained by the traffic count on 5 December 2011 (Monday), whereas the measurements of the approach speeds, speed in the circulatory roadway and on the exit from the roundabout were performed on 15 September 2011 (Thursday) in the morning peak hours in the intervals of 15 minutes using the GPS device installed onboard a passenger car, [7]. Table 4 shows the results of implementing the crash prediction model (Maycock and Hall – Turner) on the selected roundabouts.

Table 2: Traffic indicators of selected roundabouts

Traffic volume data									
Name of roundabout/road	No. of vehicles and pedestrians passing the intersection								
	no. of entries	no. of exits	circular flow	conflict flow	approach flow	(Qe+Qex)*Qp	pedestrian flow	cyclist	motorcycles
	Qe [veh/day]	Qex [veh/day]	Qc [veh/day]	Qvx [veh/day]	Qa[veh/day]	Qep[veh/day]	Qp [ped/day]	Cc [cyc/day]	P[%]
Sveti Duh - Kunišćak									
Approach 1	10032	9840	12648	2808	22680	24800256	1248	2	2
Approach 2	5184	7344	12840	5496	18024	6013440	480	2	1
Approach 3	10248	8280	10680	2400	20928	13340160	720	3	1.50
Petrova - Jordanovac									
Approach 1	11208	9384	14160	4776	25368	22239360	1080	4	1
Approach 2	3336	5808	15984	10176	19320	6803136	744	2	2
Approach 3	9216	10248	13512	3264	22728	15415488	792	4	2.5
Approach 4	4560	2880	12480	9600	17040	372000	50	2	1
Voćarska - Bijenička									
Approach 1	11472	7632	20160	12528	31632	11462400	600	2	1
Approach 2	4104	8592	18432	9840	22536	9750528	768	3	1.5
Approach 3	10464	14352	19512	5160	29976	19654272	792	1	1
Approach 4	10248	5712	15624	9912	25872	9576000	600	2	0

Table 3: Design, visibility and speed of selected roundabouts

Geometric, visibility and speed data										
Name of roundabout/road	Geometric							Visibility	Speed	
	approach curvature	entry curvature	entry width	approach width	circle diameter	island diameter	ICD/CID	angle to nex leg	visibility 10	speed of entering	speed in circulating
	$Ca[m^{-1}]$	$Ce[m^{-1}]$	e [m]	v [m]	ICD [m]	CID [m]	R	q [◦]	V_{10}[m]	S_{LL}[km/h]	S_C[km/h]
Sveti Duh - Kunišćak											
Approach 1	0.1	0.1	4	3.5	20	6	3.33	89	10	17.52	24.04
Approach 2	0.1	0.1	4	3.5	20	6	3.33	126	10	17.3	23.5
Approach 3	0.1	0.1	4	3.5	20	6	3.33	143	10	16.2	24.6
Petrova - Jordanovac											
Approach 1	0.1	0.1	4	3.5	25	12	2.08	65	10	16.96	23.4
Approach 2	0.6	0.6	4.5	3.5	25	12	2.08	97	10	24.34	26.56
Approach 3	0.1	0.1	4.5	3.5	25	12	2.08	115	10	16.52	23.31
Approach 4	0.8	0.8	5	3.5	25	12	2.08	82	10	20.42	25.34
Voćarska - Bijenička											
Approach 1	0.6	0.6	4.5	4	22	13	1.69	94	10	20.36	24.9
Approach 2	0.1	0.1	3	4	22	13	1.69	38	10	21.66	24.48
Approach 3	0.6	0.6	4.5	4	22	13	1.69	126	10	21.66	24.48
Approach 4	0.1	0.1	5	4	22	13	1.69	102	10	21.38	25.96

Table 4: Results of accident prediction models for selected roundabouts

Name of roundabout/road	METHODS									
	MAYCOCK AND HALL (1984)				TURNER (2006)					
	Entry-Circulating	Approching	Single Vehicle	Other	Entry-Circulating	Rear-end	Loss of control	Other	Pedestrian	Cyclist
	A	A	A	A	A	A	A	A	A	A
	A [injury/year]				A [crashes/year]					
Sveti Duh - Kunišćak										
Approach 1	0,135	1439572,844	0,510	0,510	0,047	29,147	0,010	0,040	494,104	0,011
Approach 2	0,023	468603,301	0,301	0,301	0,033	19,356	0,008	0,029	175,580	0,008
Approach 3	0,029	1492661,579	0,518	0,518	0,048	29,534	0,010	0,038	331,189	0,013
∑	0,187	3400837,724	1,329	1,329	0,129	78,037	0,028	0,107	1000,873	0,032
Petrova - Jordanovac										
Approach 1	0,150	1738091,61	0,557	0,557	0,048	31,220	0,011	0,041	469,462	0,016
Approach 2	0,000	1,9741E+15	0,000	0,000	0,037	14,728	0,007	0,023	166,697	0,008
Approach 3	0,093	1110700,71	0,476	0,476	0,043	27,653	0,010	0,040	368,396	0,014
Approach 4	0,000	2,9931E+19	0,000	0,000	0,036	17,877	0,006	0,020	26,841	0,009
∑	0,243	2,9933E+19	1,033	1,033	0,165	91,478	0,033	0,124	1031,397	0,046
Voćarska - Bijenička										
Approach 1	0,000	1,6116E+16	0,000	0,000	0,061	31,674	0,010	0,039	306,100	0,013
Approach 2	0,019	396576,846	0,314	0,314	0,036	16,746	0,008	0,029	235,902	0,010
Approach 3	0,000	1,3784E+16	0,000	0,000	0,056	29,919	0,012	0,047	469,694	0,009
Approach 4	0,013	1185663,24	0,653	0,653	0,060	29,534	0,009	0,034	255,724	0,012
∑	0,032	2,99E+16	0,967	0,967	0,213	107,874	0,039	0,150	1267,420	0,045
Contents: 1,97405E+15=1,97405*10^{15} or 1974054447483280; ∑- sum										

4 ANALYSIS AND COMPARISON OF RESEARCH RESULTS

The implementation of the mentioned crash prediction models at roundabouts has produced results presented in Table 4. From this table it may be concluded that the results obtained by our measurements are somewhat within the limits of feasibility compared to foreign results (see Table 1). Special attention should be paid to certain types of traffic accidents because of high deviations from the recommended values. The mentioned results for certain types of traffic accidents that are not within the limits of the recommended values are presented in Table 5. From Table 5, regarding the types of traffic accidents, the following may be concluded:

- *approaching* – recommended value of the used models for this type of traffic accidents amounts to 0.25, and in our research the model has *p*-value that is greater than 1 (see Table 5), which does not meet the mentioned criteria;
- *pedestrian* – recommended value of the used models for this type of traffic accidents amounts to 0.17, and in our research the model has *p*-value which is greater than 1 (see Table 5), which does not meet the mentioned criteria;
- *rear-end* – recommended value of the model for this type of traffic accident amounts to 0.26, and in our research the model has *p*-value which is greater than 1 (see Table 5), which does not satisfy the mentioned criteria.

Whereas regarding the statistical overview and the frequency of traffic accidents over one year at the observed intersections the number of traffic accidents is not large, the results of used methods foresee a certain value, i.e. a number of single types of traffic accidents and injuries.

Table 5: Preview of calculated values and their deviations from the limit values

Name of roundabout/road	METHODS			
	MAYCOCK AND HALL		TURNER	
	Approching	Pedestrian	Rear-end	Pedestrian
	A	A	A	A
	A [injury/year]		A [crashes/year]	
Sveti Duh - Kunišćak				
Approach 1	1439572,844	144,420	29,14677	494,104
Approach 2	468603,301	71,115	19,35631	175,580
Approach 3	1492661,579	105,920	29,53428	331,189
∑	3400837,724	321,454431	78,03736	1000,87307
Petrova - Jordanovac				
Approach 1	1738091,61	136,760	31,22034	469,462
Approach 2	1,9741E+15	75,640	14,72754	166,697
Approach 3	1110700,71	113,861	27,65327	368,396
Approach 4	2,9931E+19	17,688	17,87674	26,841
∑	2,9933E+19	343,949252	91,4779	1031,397
Voćarska - Bijenička				
Approach 1	1,6116E+16	98,183	31,67426	306,100
Approach 2	396576,846	90,555	16,7463	235,902
Approach 3	1,3784E+16	128,566	29,91871	469,694
Approach 4	1185663,24	89,741	29,53428	255,724
∑	2,99E+16	407,045	107,873	1267,420
Contents: 1,97405E+15=1,97405*10^{15} or 1974054447483280; ∑- sum				

5 CONCLUSION

The goal of this paper is to check in domestic conditions the compatibility of the level of safety and the number of traffic accidents at roundabouts in the City of Zagreb with the foreign crash prediction methods. The results of the comparison indicate that the mentioned models cannot be implemented in our conditions (see Tables 3 and 4) because of the values for a certain type of traffic accidents which are not within the recommended limit values. The majority of the calculated models is below the recommended limits (p-value $\geq$ 0.05 – inadequate model) which certainly represents a drawback of adequate assessment of the model selection. The reason for the drawbacks of this model can be considered in insufficient observation of the roundabouts. Due to a relatively small number of data within the frames of this research, one can speak only about the basic insight into the crash prediction models at roundabouts in the city of Zagreb.

Furthermore, it is necessary to carry out a systemic monitoring of the traffic flows, level of safety, and detailed research of the designability at the existing roundabouts in Croatia in order to identify best the drawbacks and advantages of the respective intersections. Special attention should be paid to the collection of data regarding the number and types of traffic accidents not only by MUP but also by the insurance companies so as to obtain high-quality and coordinated traffic databases, that could be used for further scientific and professional research.

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