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Ivan Legac, Hrvoje Pilko, Nikola Šubić
University of Zagreb - Croatia

Introduction of Roundabouts in Croatia – - preliminary Experiences

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1. **Introduction**
2. **Regulations, Classification, Design**
3. **Observed Problems**
4. **Current Research**
5. **Conclusion**

Ad 1) Introduction in Croatia/HR

- **in HR: postponed replays in CEC (inexperience, distrust, without guidelines)**
- **around 130 roundabouts, predominant new generation/after 1990.**
- **all analysis and designing were from foreign standards (UK , US , AUS, NL, A ...)**

Ad 2) Regulations, Classificaton, Design

- **Acts on Roads (1994., 1996.), Traffic Strategy (1999.), Design Elements (1999.)**
- **Guidelines for roundabouts – proposals (2002-2004.)**
- **Classification according location and size (mini - , small - , middle - , big -)**
- **Design elements from foreign standards (UK, AU, NL, A, G...)**

Ad 3) Observed Problems

- **general study of safety problems in the last 2-3 years**
- **bigger problems with capacity analysis are generally observed in the last 10-20 years**
- **in the past war period (1991-1995.) we accepted roundabout right-of-way and reduced number of lanes**
- **it remained dilemmas: greater or smaller entry angle (UK, US, F) or verticalizing / i.e. reducing of speed to roundabout (G).**

Ad 3) Observed Problems

Heterogeneous HR-solutions are consequence of:

- **absence of national regulations/standards**
- **inadequate design (without spacial traffic analyses)**
- **under-capacity designs (with queues at approaches)**
- **realized roundabouts with inadequate equipment**

Ad 3) Observed Problems

Figure 1. One of the oldest roundabout (Petr. – Domj. Str. in Zagreb, 1950)

Figure 2. Big roundabout (Dv = 148 m, n = 3/3) Jadr. Ave. – Remet. Str. at entrance in Zagreb, 1980.

Figure 3. New solution of roundabout, (Varaždin - bypyss south, 2005.)

Ad 3) Observed Problems

- **Last analysis of capacity (C_k) according designing of roundabout, were:**

  - Australian and Austrian/Swiss methodology

  - German (for pedestrian) and Nederland methodology (for bicyclist) in roundabout

Ad 3) Observed Problems

- Capacity (q_u entry) on Universal formula according to Ning Wu

$$q_{u,max} = \left[1 - \frac{\lambda \cdot q_k}{n_k}\right]^{n_k} \cdot \frac{n_u}{t_{sl}} \cdot exp[-qk \cdot (t_0 - \lambda)]$$

$q_{u,max}$ – cap. of entry (PCU/h); q_k – vehicles in roundabout (PCU/h); n_u/n_k – number of lanes in entry/in roundabout (-); λ – min. time gap between vehicles in roundabout (s)

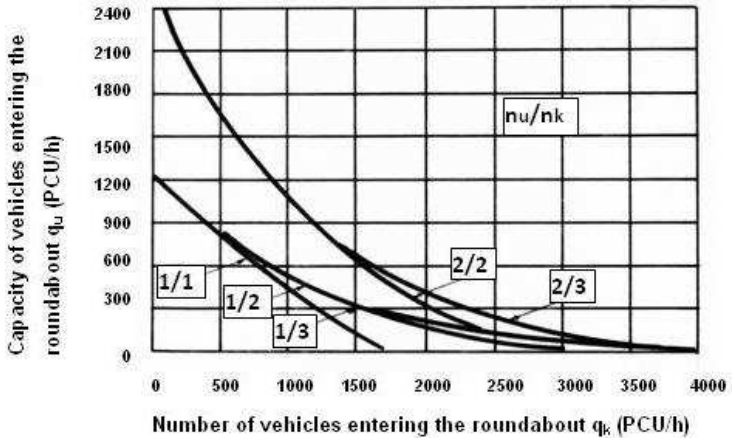


Figure 3. Correlation q_u/q_k according to Ning Wu

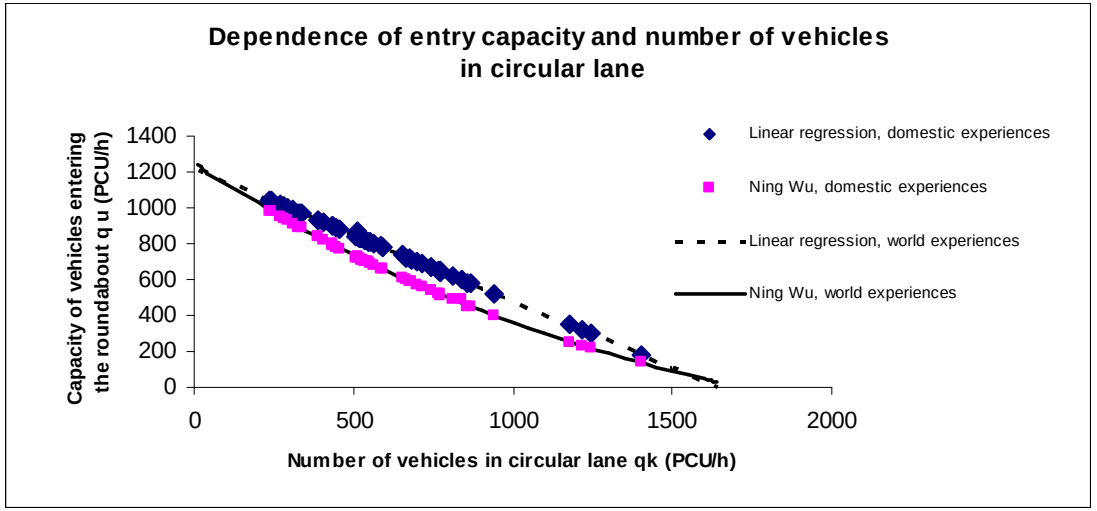


Figure 4. Measured q_u/q_k (Linear regr., Ning Wu) in world and in Croatia

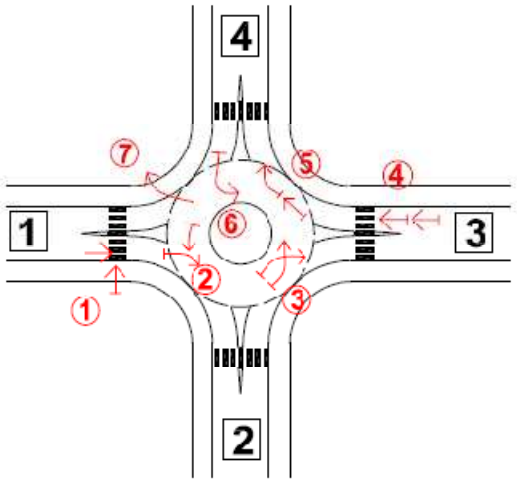
Ad 4) Current Research

- **Optimizing road intersections (2003-2006)**
- **Guidelines for urban intersection design (2004)**
- **Public road intersections / Roads II. (2008)**
- **Correlation of design and safety at intersections with circular traffic flow (2008-2011)**

Ad 4) Current Research

- **Correlation of design and safety at intersections with circular traffic flow (2008-2011):**

- accidents at approach and entry into the intersection
- accidents in the central circulatory roadway
- accidents at the exit from the roundabout



Collisions:
1. Car-pedestrian collision
2. Failure to yield at entry (entering)
3. Weaving in circulatory roadway
4. Rear-end at entry
5. Rear-end at exit
6. Wrong direction in circulatory roadway
7. Single vehicle run off circulatory roadway

Figure 5. Diagram of collisions in roundabout

Ad 4) Current Research

- **Creating conclusions and measures for safer roundabouts**
- **Intersection geometry / number of accidents are follow-up of the research of Maycock and Hill:**

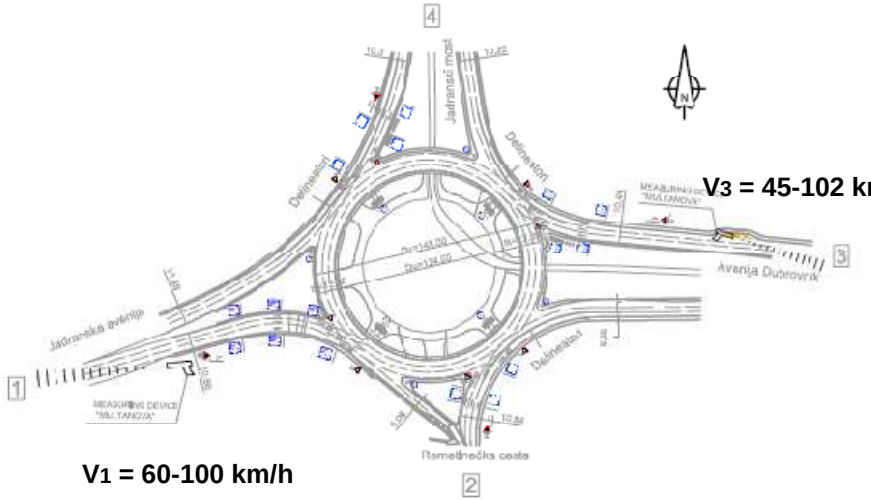
- relation accidents / angle of two adjancent legs,
- entry / exit width into / from the roundabout,
- roadway width in the roundabout.

Figure 6. Direct weaving of cars, bicyclists and pedestrians by independent guiding (Varaždin bypass, 2005)

Ad 4) Current Research

- **Design / Traffic Safety**

a) Jadran. Ave. - Remet. Str.



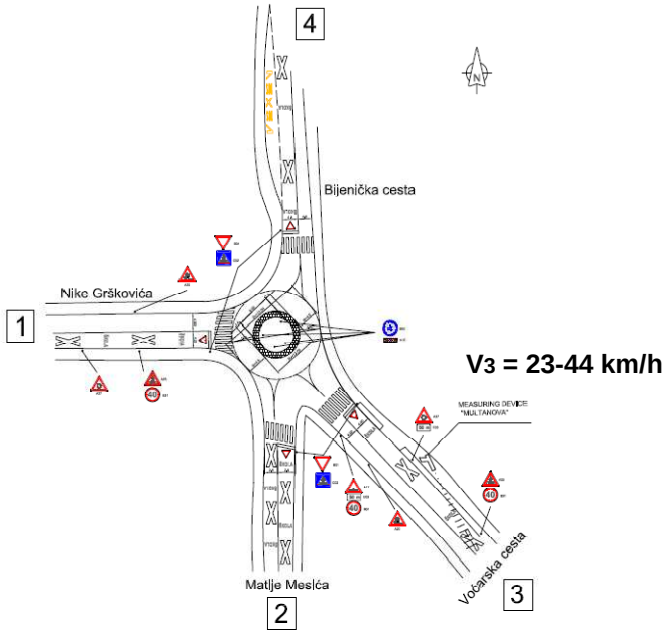
V_3 = 45-102 km/h

V_1 = 60-100 km/h

Jadranska Av. - Remetinečka Street			
TYPES OF TRAFFIC ACCIDENTS	2008. y.	2007. y.	2006. y.
1. Car-pedestrian collision	0	2	0
2. Failure to yield at entry (entering)	5	12	20
3. Weaving in circulatory roadway	44	42	47
4. Rear-end at entry	38	44	39
5. Rear-end at exit	2	3	3
6. Wrong direction in circulatory roadway	0	0	0
7. Single vehicle run off circulatory roadway	15	21	20
TOTAL	104	124	129

CONSEQUENCES OF TRAFFIC ACCIDENTS	2008. y.	2007. y.	2006. y.
1. Killed	0	0	0
2. Injured	14	19	22
TOTAL	14	19	22

b) Voćarska – Bijenička Str.



V_3 = 23-44 km/h

Voćarska - Bijenička Street			
TYPES OF TRAFFIC ACCIDENTS	2008. y.	2007. y.	2006. y.
1. Car-pedestrian collision	0	1	0
2. Failure to yield at entry (entering)	0	0	1
3. Weaving in circulatory roadway	0	0	0
4. Rear-end at entry	0	0	0
5. Rear-end at exit	0	0	0
6. Wrong direction in circulatory roadway	0	0	0
7. Single vehicle run off circulatory roadway	0	0	0
TOTAL	0	1	1

CONSEQUENCES OF TRAFFIC ACCIDENTS	2008. y.	2007. y.	2006. y.
1. Killed	0	0	0
2. Injured	0	1	0
TOTAL	0	1	0

Ad 5) Conclusion

- **In Croatia we have around 130 roundabouts (85 in urban areas)**
- **Other 60% of them are built after 1990 / by new design standards**
- **There is a direct link between design and capacity i.e. safety**
- **Concerning new analysis on 30 locations in Zagreb, there are:**
  - level of usage is 56%;
  - level of safety is 3,23 (evaluated 1 to 5).

Thank You for Your attention!