Introduction of Roundabouts in Croatia – preliminary Experiences
I. Legac, H. Pilko, N. Šubić: Roundabouts in Croatia – preliminary Experiences

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, Classification, Design

- 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

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

$q_{u,\text{max}}$ – cap. of entry (PCU/h); $q_k$ – vehicles in roundabout (PCU/h); $n_u/n_k$ – number of lanes in entry/in roundabout (-); $\lambda$ – 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 adjacent 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**
  

  - $V_1 = 60-100\ km/h$
  - $V_3 = 45-102\ km/h$

b) Voćarska – Bijenička Str.

  - $V_3 = 23-44\ km/h$

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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!