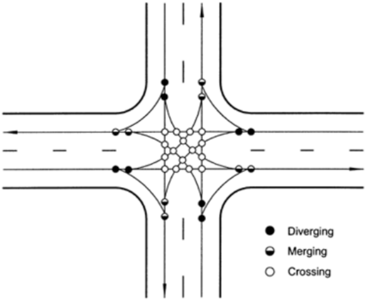
CE 269
Traffic Engineering

Lecture 16

Roundabouts and Simulators

Previously on Traffic Engineering

Consider the following 4-way junction. For the unsignalized version, there are 8 merge and 8 diverge conflicts and 16 crossing conflicts.



These reduce the capacity and also make navigating through the junction less safe.

Lecture Outline

1. Roundabouts
2. Simulators for Intersections

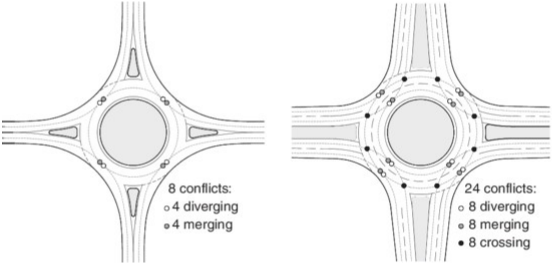
Lecture Outline

Roundabouts

Roundabouts

Introduction

Roundabouts/rotaries/traffic circles are alternate to traffic signals and can reduce crossing conflicts.



Several studies have found that roundabouts have more capacity than using four-way stops or signals. Since they have fewer conflicts, they tend to be safer as well.

https://youtu.be/BvNO8LWVfAg

Roundabouts

Advantages and Disadvantages

Advantages:

- Complete stops are avoided. This can improve air quality.
- Signals or traffic police aren't needed. Operational costs are lower.
- Intersections with more than four approaches can also be effectively handled using roundabouts.

The Arc de Triomphe roundabout with 12 approaches
https://youtu.be/FXfGZF2-sUU

Roundabouts

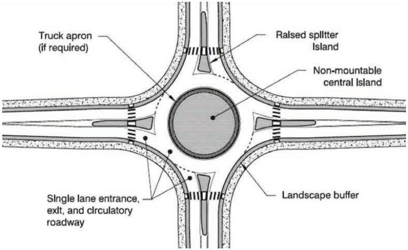
Advantages and Disadvantages

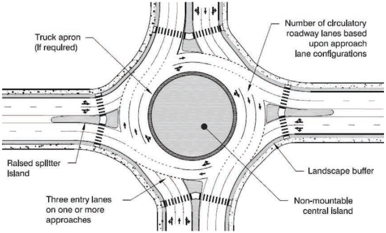
Disadvantages:

- Not ideal for high volume conditions.
- Vehicles slow down significantly when navigating through a roundabout which can increase the overall delay.
- Requires users to be familiar with the layout.
- Require more real estate.
- Pedestrians have to cross streets searching for gaps.

Roundabouts

Types

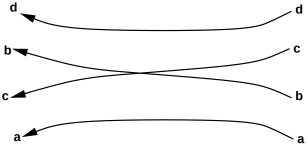


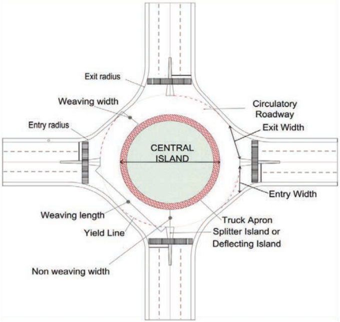


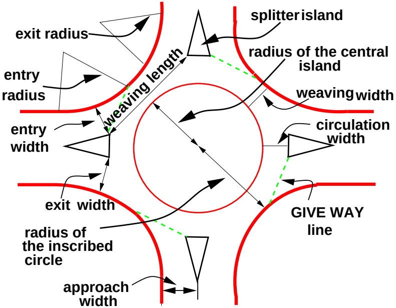
Roundabouts

Geometric Design

In a roundabout, drivers exhibit merge and diverge actions which is referred to as weaving.





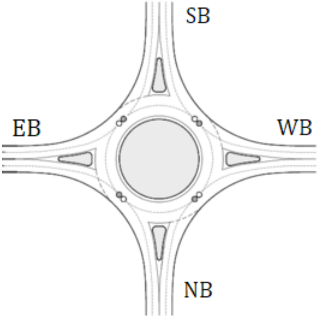


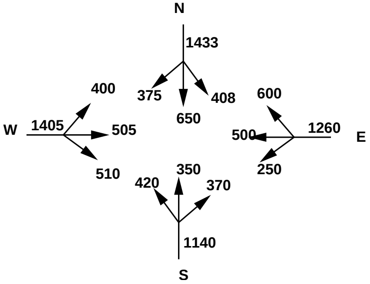
The capacity of a roundabout depends on the above geometric design elements as well as the circulating flow. As the circulating flow increases, the capacity decreases and delay increases.

Roundabouts

Flow Parameters

Consider a four-way roundabout. Let $Q_{e1}, \ldots, Q_{e4}$ be the approach volumes or entry flows and $Q_{c1}, \ldots, Q_{c4}$ be the circulating volume.



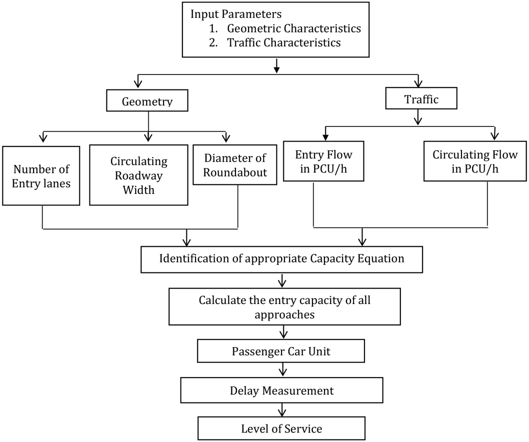


Calculate the circulating flow for the traffic going EB in the above example.

Roundabouts

Capacity and LoS

LoS calculations are based on delay which is the sum total of geometric delay (caused due to speed reduction) and queuing delay (required for weaving)



Roundabouts

Gaps

Critical Gap: Critical gap is defined as the minimum headway in the circulating flow when an entering vehicle can safely enter a roundabout, assuming all entering drivers are consistent and homogeneous.

Follow-up Time: Follow-up time is defined as the time span between two queued vehicles entering the circulating stream in the same gap. If more than one vehicle from minor stream uses a gap then the succeeding vehicles are referred to as follow-ups.

How do these change with increase in the diameter of a roundabout?

Roundabouts

Inputs

The HCM formulae were derived for roundabouts with diameter in the range 20-70 m and with two lane approaches. The following input parameters are required for estimating capacity and LoS.

Parameter	Description	Remarks
Geometric Characteristics	1. Diameter of the Roundabout *in m* 2. Number of Approach Lanes 3. Approach Width *in m* 4. Number of Circulating Lanes 5. Circulating Roadway width *in m*	Field measurements
Traffic Characteristics	1. Entry Flow in veh/h *(Q_e)* 2. Circulating Flow in veh/h *(Q_c)*	Video Extraction
	3. Passenger Car Units *(PCU)* 4. Entry Flow in PCU/h *(Q_e)* 5. Circulating Flow in PCU/h *(Q_c)*	Conversion of traffic flow to PCU
Driver Behaviour	1. Critical Gap, T_c *(sec)* 2. Follow-Up Time, T_f *(sec)*	Computed

Roundabouts

PCUs and Gaps

Flows are first converted to PCUs using the following factors.

Diameter *(in m)*	Motorized Traffic						Non-Motorized Traffic		
	Two-Wheeler	Autos	Small Cars	Big Cars	LCVs	Heavy Vehicles	Cycle	Cycle Rickshaw	ADV
20 <D ≤ 30	0.32	0.83	1.00	1.40	1.88	3.65	0.18	1.12	4.0
30 < D ≤40					1.65	3.45	0.21	1.31	
40 < D ≤50					1.53	3.20	0.25	1.56	
50 < D ≤70					1.46	3.05	0.28	1.74	

Critical gap and follow-up time can be read off from this table.

Diameter, D *(m)*	Critical Gap*(sec)*	Follow-up Time *(sec)*
20 < D ≤30	2.00	1.50
30 < D ≤40	1.90	1.40
40 < D ≤50	1.65	1.25
50 < D ≤70	1.60	1.20

Roundabouts

Capacity

Let T_f and T_c be the follow-up time in seconds Q_c be the circulating flow in PCU/hr.

The capacity of an approach of a roundabout is given by

$$C = Ae^{-BQ_c}$$

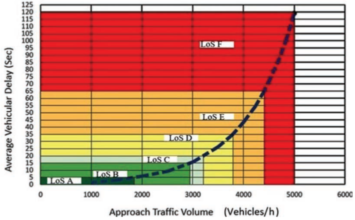
where $A = 3600/T_f$ and $B = (T_c - 0.5T_f)/3600$

The overall capacity of the roundabout is derived by combining the approach capacities with observed flows in other approaches.

The total delay can be estimated using

$$y = 0.8e^{0.001x}$$

where y is the vehicular delay in seconds and x is the total approach traffic in veh/hr (not PCU/hr)



LOS	Average Delay 'd' per Vehicle *(Sec)*
A	≤ 5
B	6 ≤ d ≤ 15
C	16 ≤ d ≤ 20
D	21 ≤ d ≤ 35
E	36 ≤ d ≤ 65
F	> 65

Roundabouts

Example

Estimate the Capacity and LoS of a roundabout with diameter 66 m with 2 lanes in each approach with the following flows.

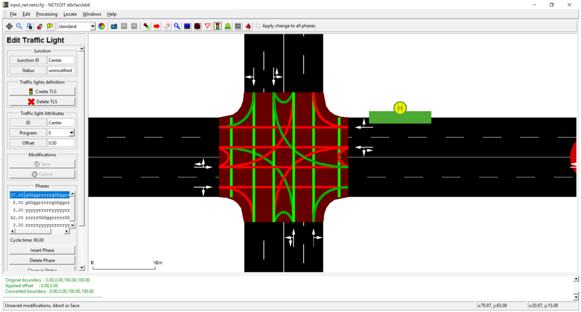
Entry Flow *(in Vehicles/h)*							
Total		**Small Cars**	**Big Cars**	**Light Commercial Vehicles**	**Heavy Vehicles**	**Two Wheelers**	**Three Wheelers**
Arm 1 (Q_{e1})	1641	762	283	5	35	423	133
Arm 2 (Q_{e2})	418	174	56	10	15	128	35
Arm 3 (Q_{e3})	1570	837	145	15	47	359	167
Arm 4 (Q_{e4})	788	361	142	20	27	181	57
Total	**4417**						

Circulating Flow *(in Vehicles/h)*							
Total		**Small Cars**	**Big Cars**	**Light Commercial Vehicle**	**Heavy Vehicles**	**Two Wheelers**	**Three Wheelers**
Circulating Section1(Q_{c1})	754	279	162	12	25	198	78
Circulating Section2(Q_{c2})	1767	978	235	10	37	380	127
Circulating Section3(Q_{c3})	349	137	87	8	17	57	43
Circulating Section4(Q_{c4})	1457	647	162	10	47	510	81
Total	**4327**						

Lecture Outline

Simulators for Intersections

Create a signalized intersection in SUMO and assign demands for different turn movements.



Tweak the phasing scheme and estimate the average delays of all vehicles.

Your Moment of Zen