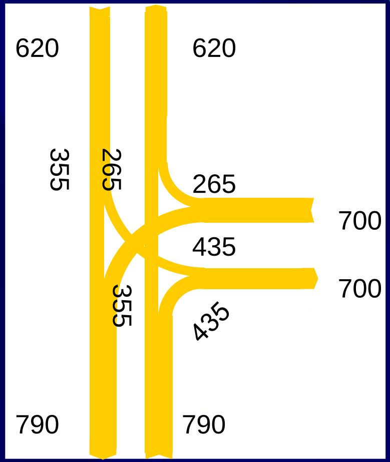
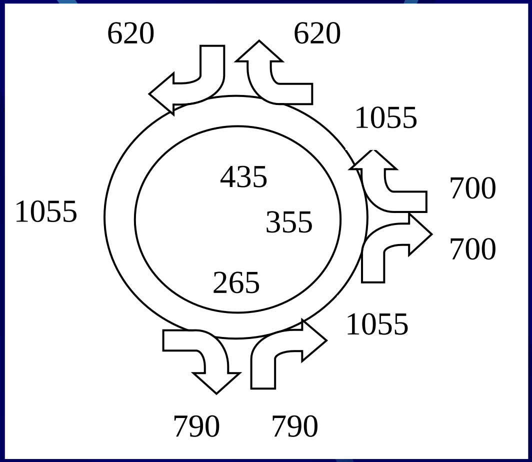
Traffic design of urban roads and intersections





Transport networks practice 7-8.

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Traffic design of urban roads

The aim of the traffic based design at a cross section is to ensure that the peak hour traffic volume (traffic flow) is less or equal to the allowable traffic volume $F_{all} \geq PeakHourTraffic$.

The allowable traffic volumes are prescribed in standards or technical guidelines.

In the Hungarian technical guidelines there are four categories of urban roads with appropriate allowable traffic volumes.

Traffic design of urban roads

Network function „a”: main road that determines settlement structure, mainly connection function with through traffic, less important are distribution or service functions.

Network function „b”: main road that partially determines settlement structure, distribution function is present besides connection function.

Network function „c”: element of local settlement structure, proportional distribution and service functions, with constrained connection function.

Network function „d”: road for service function, the distribution function is controlled, no connection function.

Traffic design of urban roads

Capacity of urban roads (Hungarian standard)

Network function	Traffic volume pcu/h	
Level of service	adequate	allowable
2*2 or more lanes „a” function: 1 lane	1200	1600
2*2 lanes „b” function: 1 lane	900	1300
2 lanes „a” function: 2 lanes	1500	2000
2 lanes „b” function: 2 lanes	1000	1200
2 lanes „c” function: 2 lanes	800	1000

Traffic design of urban roads

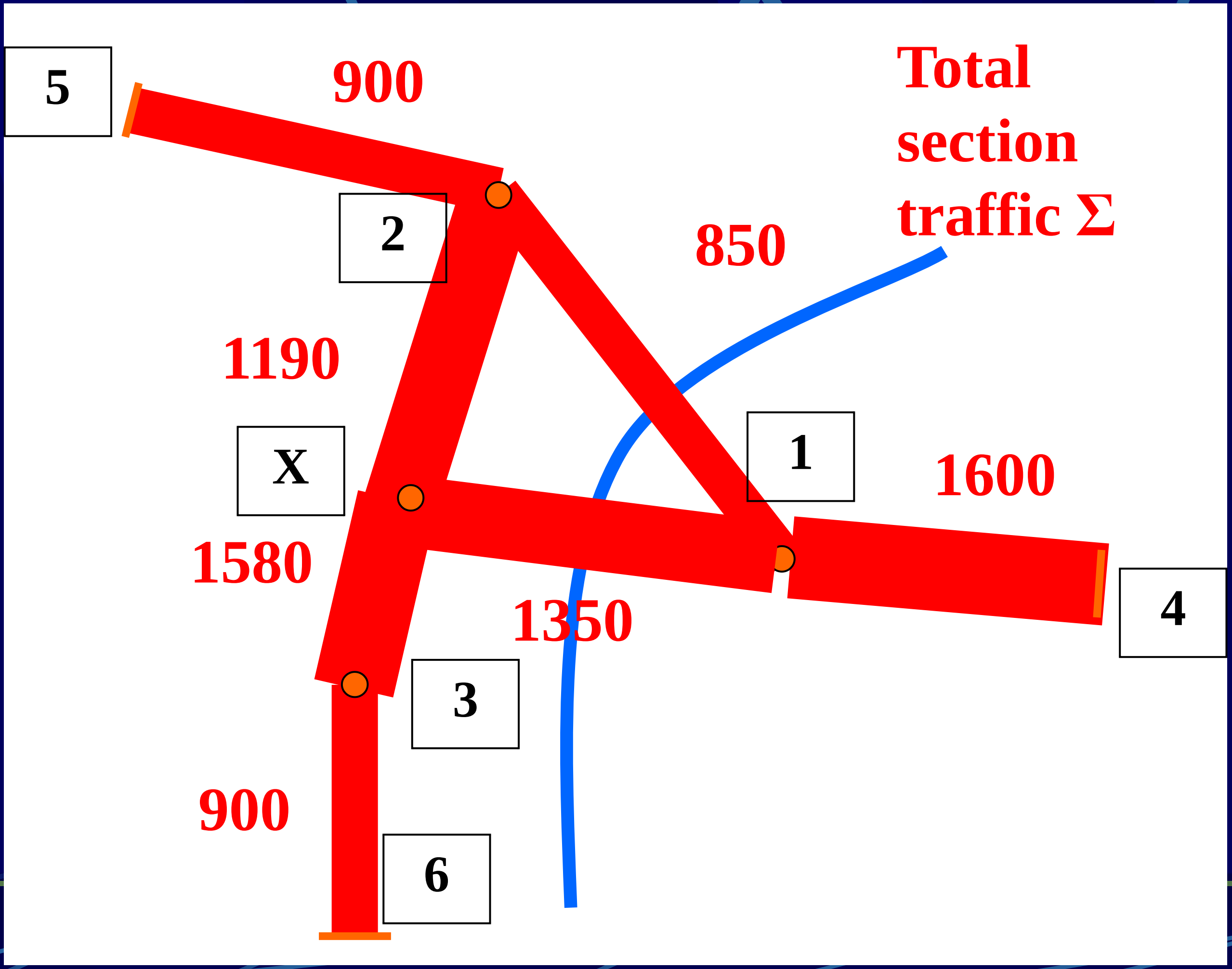
Capacity volumes are given for one lane in case of 2 or more lanes per direction and for two lanes together in case of 2 lane roads.

Capacity reduction factors must be considered for: distance of junctions, parking lane, bus lane, access to properties, bus stop, pedestrian crossing, pavement width etc.

Value of a reduction factor is usually 0,8 - 0,9.

Traffic design of road sections

Example result – assigned traffic – start point



Traffic design of road sections

Number of traffic lanes

section	traffic	capacity (2 lanes)	number of lanes
1 – X	1350	1500	2
X – 2	1190	1500	2
X – 3	1580	1500	4

Traffic design of intersections

Traffic volume and safety demand together determine the type of the junction.

In the design of a junction equally must be ensured for vehicles, bicycles and pedestrians:

- **recognisability,**
- **transparency,**
- **perceptibility,**
- **viability (i.e. widening of curves),**
- **reduction of the number of stops, decelerations and accelerations.**

Basics of signalised intersections

Intersections under traffic signal control operate on the basis that separate time periods are allotted to conflicting traffic movements so that each can make safe and efficient use of the carriageway space available.

Traffic signals are usually installed only at at-grade intersections in built-up areas.

The main goal is to reduce time losses in the junction.

A detailed geometric design of elements is required.

Basics of signalised intersections

Phase: Group of movements permitted at the same time (green signals at the same time). In a four-leg intersection there are 12 possible movements to be grouped into phases.

Time period (P): Time between repeated signal patterns. Usual time periods applied: 60...90...120 s.

Phase timing plan: Splitting period into green times and intermediate times. Each signal group giving the same colour at the same time has its own row in the phase timing plan. There are also rows for pedestrian and bicycle movements.

Basics of signalised intersections

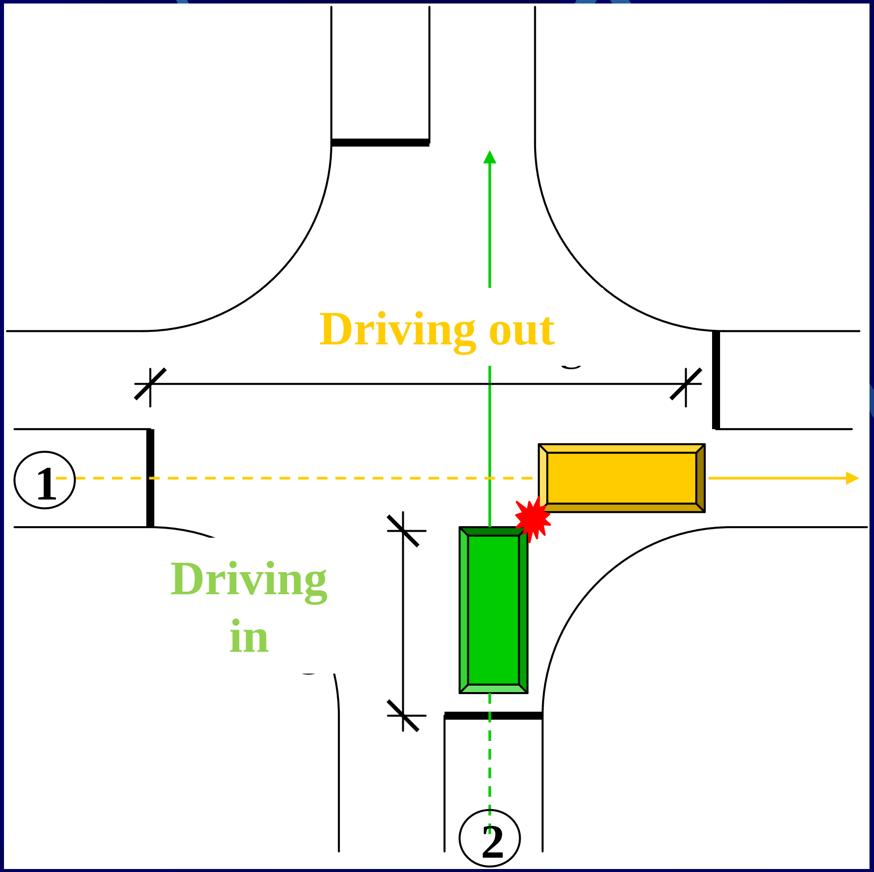
Intermediate time (t_{im}): in case of crossing or weaving movements this is the time between the end of the green time of the driving out and the start of the green time of the driving in rounded to secs for safety reasons.

Driving out time (t_{out}): time for driving from the stop line to the far end of the collision zone plus one vehicle length (6 m).

Driving in time (t_{in}): time for driving from the stop line to the near end of the collision zone.

Basics of signalised intersections

Intermediate time



Basics of signalised intersections

Intermediate times for vehicle and pedestrian movements: must be calculated for every pair of possible conflicts (matrix of intermediate times).

Important for traffic safety.

Intermediate time =

= yellow time + driving out time – driving in time

Driving in speed is larger than driving out speed.

Basics of signalised intersections

<u>Fix program control:</u> different programs (phase timing plans) for various parts of the day – morning peak, afternoon peak, daytime normal. Programs are changed by a clock at previously given points. This type of control is out-of-date.

<u>Traffic dependent control:</u> there are 2 traffic volume sensors in the approaching lanes – one is near the stop line (4 – 5 m) the other is at further distance (40 -60 m). The order of phases is given. It is possible to lengthen or shorten green times, even leaving out a phase.

<u>Adaptive traffic control:</u> every junction controller in every period gets its own phase timing plan according to area-widely measured traffic volume data.

Basics of signalised intersections

Unopposed streams: phases without conflicts. The intersecting movements have got no same time green (excepting right turning vehicles and crossing pedestrians). An arrow in the signal head is possible only in this case. Recommended in higher turning traffic volumes.

Partially opposed streams: phases with conflicts (full green). Movements from opposite direction (straight and turning) may have green signal at the same time (and parallel pedestrians as well). Basic traffic rules are valid. No arrows in the signal head. Recommended when left turning traffic is smaller.

Basics of signalised intersections

Capacity (C, calculated for each phase and together):

$$C = (F / 2{,}0) * (3600 / P) \quad [pcu/h]$$

$$\text{Saturation rate} = \frac{\text{peak hour traffic}}{\text{capacity}}$$

Approximate length of vehicle sorting section:

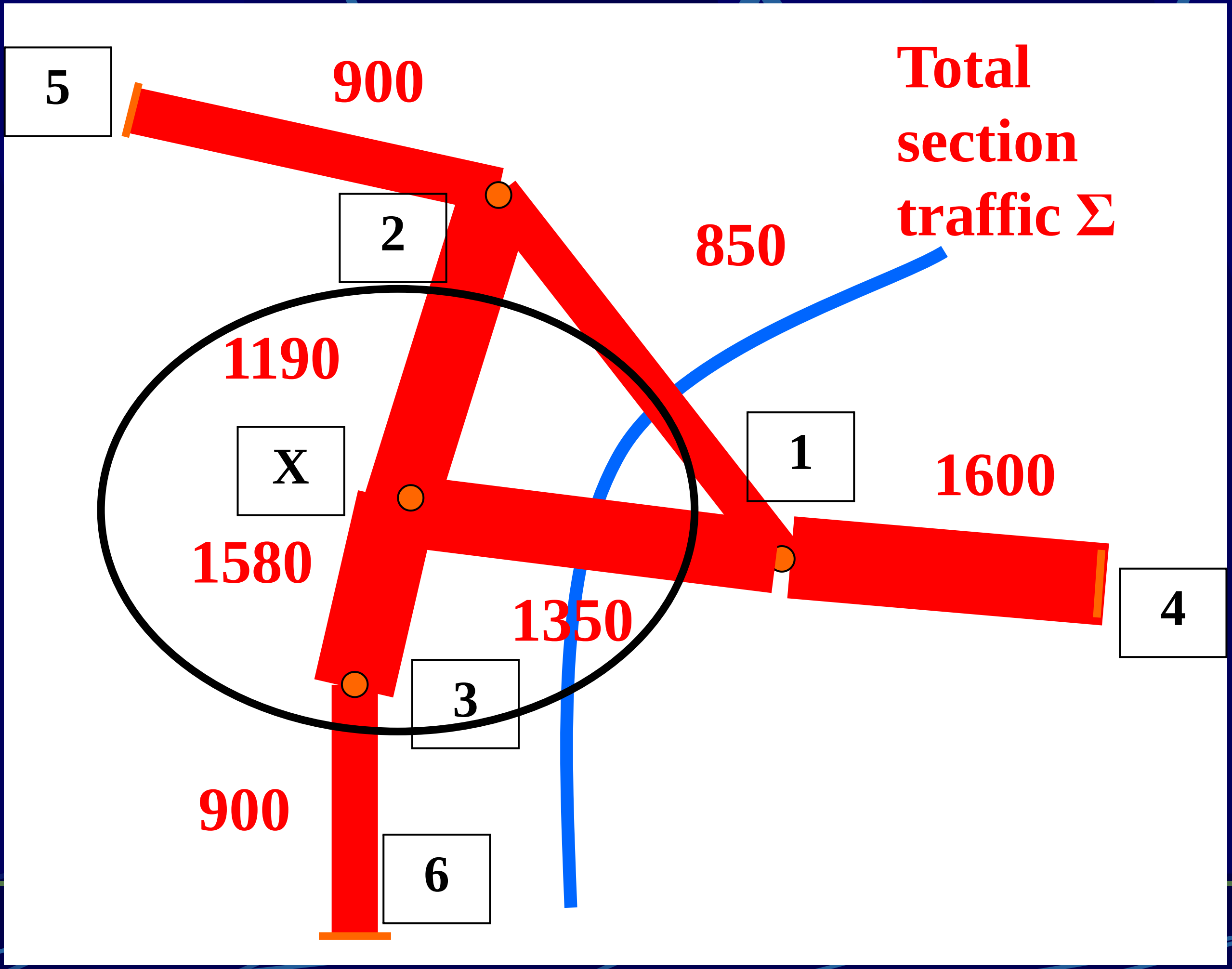
$$L_o = 0{,}09 * V + 30 \quad [m]$$

Approximate length of vehicle waiting section:

$$L_f = 6 * (P – G) / 2 \quad [m]$$

Example of a signalised intersection design

Intersection „X” at the new bridge



Example of a signalised intersection design

In a three-leg intersection the movements (right, straight, left) can be calculated unambiguously.

leg	1	2	3
1		(A+B-C)/2	(A+C-B)/2
2	(A+B-C)/2		(B+C-A)/2
3	(A+C-B)/2	(B+C-A)/2	

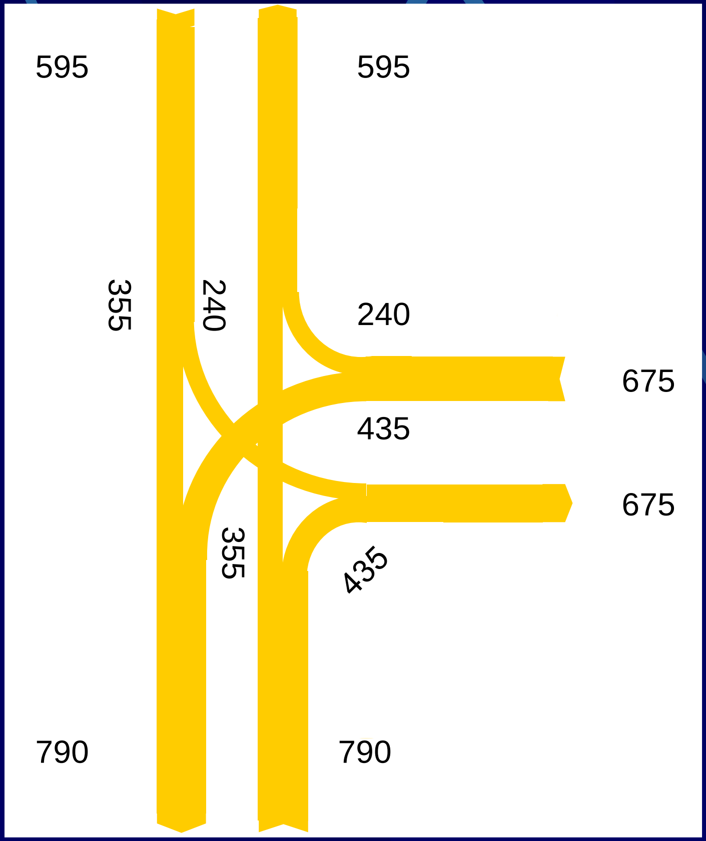
Example of a signalised intersection design

Intersection movements traffic matrix

leg	1	2	3	sum
1	0	240	435	675
2	240	0	355	595
3	435	355	0	790
sum	675	595	790	

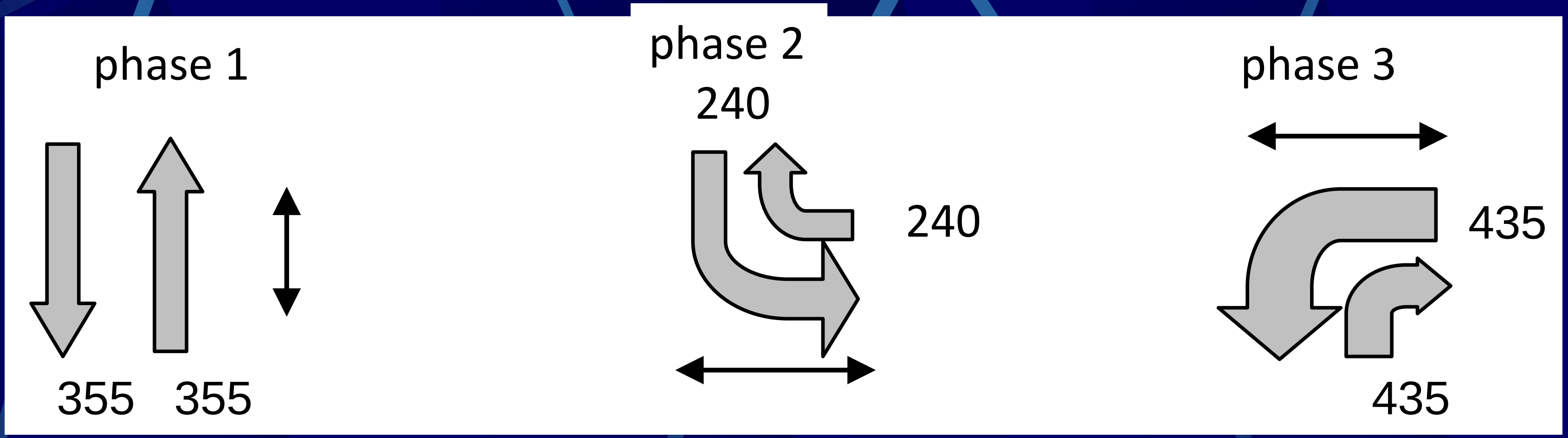
Example of a signalised intersection design

Intersection movements figure



Example of a signalised intersection design

Phase order of movements including pedestrians



Time period: **90 s**

Intermediate time: **3 * 5 = 15 s**

Max. green time: **90 – 3 * 5 = 75 s**

Capacity reserve distribution proportionally

Example of a signalised intersection design

Design of green times: $Z_{min} = (F * 2{,}0) / (3600 / P)$

For pedestrians: minimum 15 s

	traffic pcu/h	green time s at least	green time s designed	capacity saturation
phase 1	355	18	26	68 %
phase 2	240	12 >>15 (pedestrians)	18	67 %
phase 3	435	22	31	70 %

Basics of roundabouts

Traffic safety in roundabouts is usually better.

A roundabout has a special geometry and signing.

There can be 3 - 6 legs in a roundabout.

Recognisability and perceptibility are important.

Viability is very important for oversized vehicles.

Nowadays it is a stylish intersection type.

Basics of roundabouts

The roundabout is especially recommended at intersections of roads of the same category with similar traffic volumes.

On a given road section mixing the signalised type and roundabouts is not recommended.

In a special case a tram track can cross the roundabout.

A well designed roundabout may have an urban structural and space forming role.

Speed is less therefore pollution is reduced.

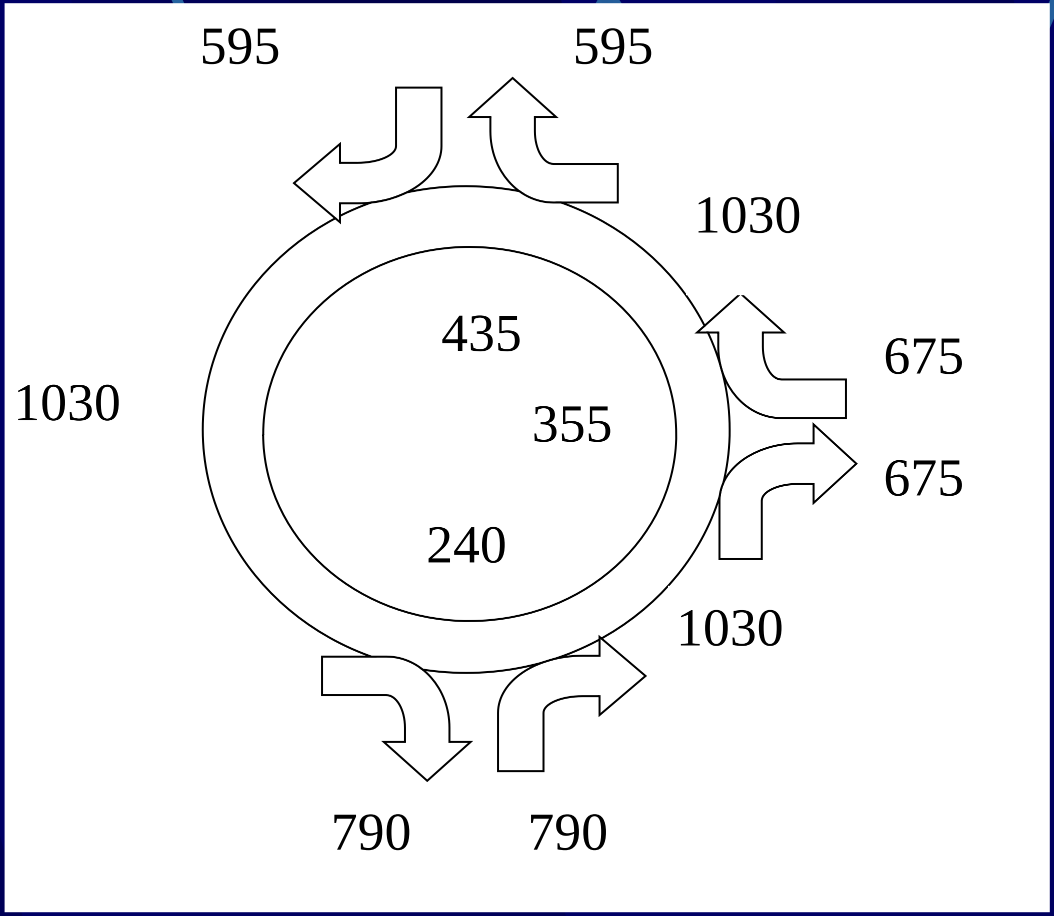
Basics of roundabouts

Parameters determining capacity:

- **entry (drive in) width,**
- **number of entry lanes,**
- **arrival width,**
- **number of lanes in the circular track,**
- **width of circular track,**
- **drive out width,**
- **distance of conflict points,**
- **radius of the central island,**
- **entry angle.**

Example of a roundabout design

Intersection movements figure



Example of a roundabout design

In a three-leg intersection the traffic of the circular track can be calculated unambiguously.

FK = (A + B + C) / 2

Design consists of determining the number of circular lanes as well as the entry capacity and saturation of legs.

	traffic	capacity	lanes
circular track	1030	1200	1

Example of a roundabout design

leg	circular traffic	entering traffic	entry capacity	capacity saturation
1	355	675	1148	59 %
2	435	595	1076	55 %
3	240	790	1259	63 %

entry capacity (simplified): $1525\ e^{-0{,}0008\ F_{circular}}$

Example of a roundabout design

- Capacity saturation of the roundabout in the analysed example proved to be better than that of the signalised intersection.
- Presence of pedestrians (depending on their traffic volume) may decrease the entry capacity of the roundabout.
- The analysed example applied only simplified methods, the real design process is usually more sophisticated.

Summary

- The task of traffic design is to provide adequate number of lanes and proper intersection types according to the peak hour traffic flow.
- In signalised intersections intermediate times must be calculated for every pair of possible conflicts.
- Traffic safety and capacity saturation in roundabouts are usually better, however it requires more space.
- Special attention is required for pedestrians and cyclists.

Thank you for your attention!

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