AT-GRADE JUNCTION

Basic concepts

- Angle „α“ at which the major and minor road cross
  $75° \leq \alpha \leq 105°$
- ***The** angle is defined **between** connection of points **AX and CX for the purpose of the exercise** – fig. 0520*

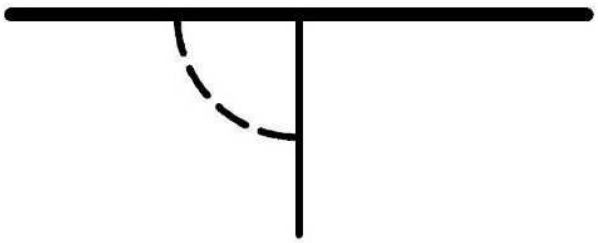


fig. 0520 (crossing angle on T-junction)

- Slip road – road lane or carriageway which connects at-grade junction legs in area outside of the junction centre (separated from leg by traffic island or ghost island (hatched road marking) – *fig. 0530*)
- Junction corner – area between road edge of at-grade junction and outer edges of intersecting traffic lanes (enables smooth right turn – *fig. 0530*)

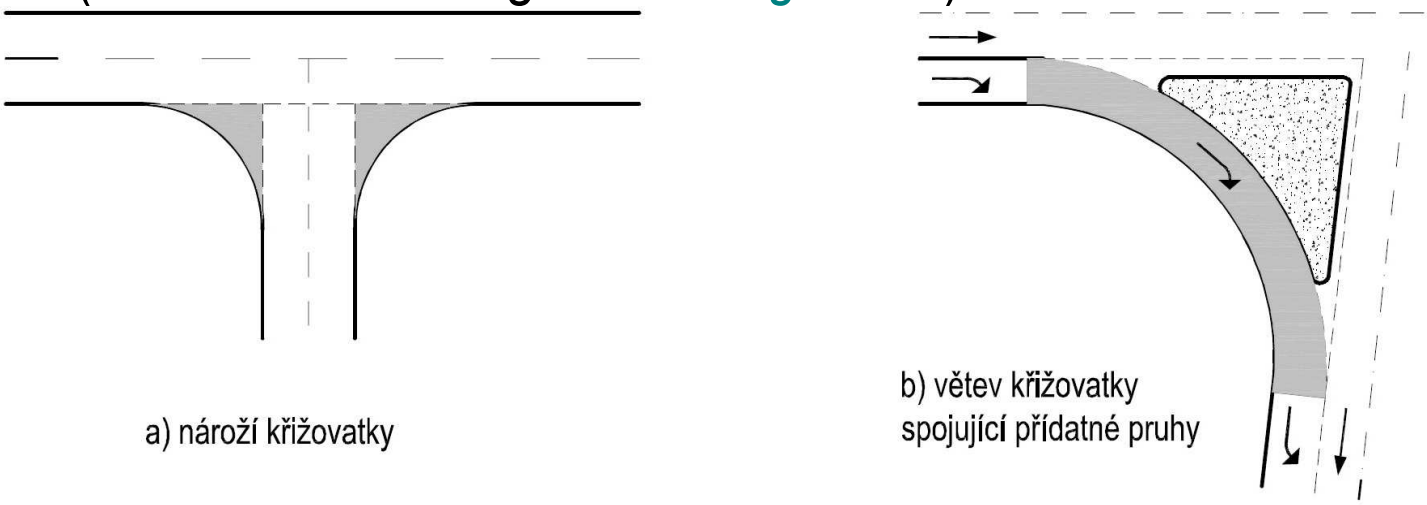


fig. 0530 (corner and slip road on at-grade junction)

PRINCIPLES OF JUNCTION DESIGN

- Place the junction on horizontally straight section or on the outer edge of horizontal curve with large radius – see *fig. 0540*
- Place the junction on vertically straight section with longitudinal gradient ≤ 3% or in a sag curve – *fig. 0540*

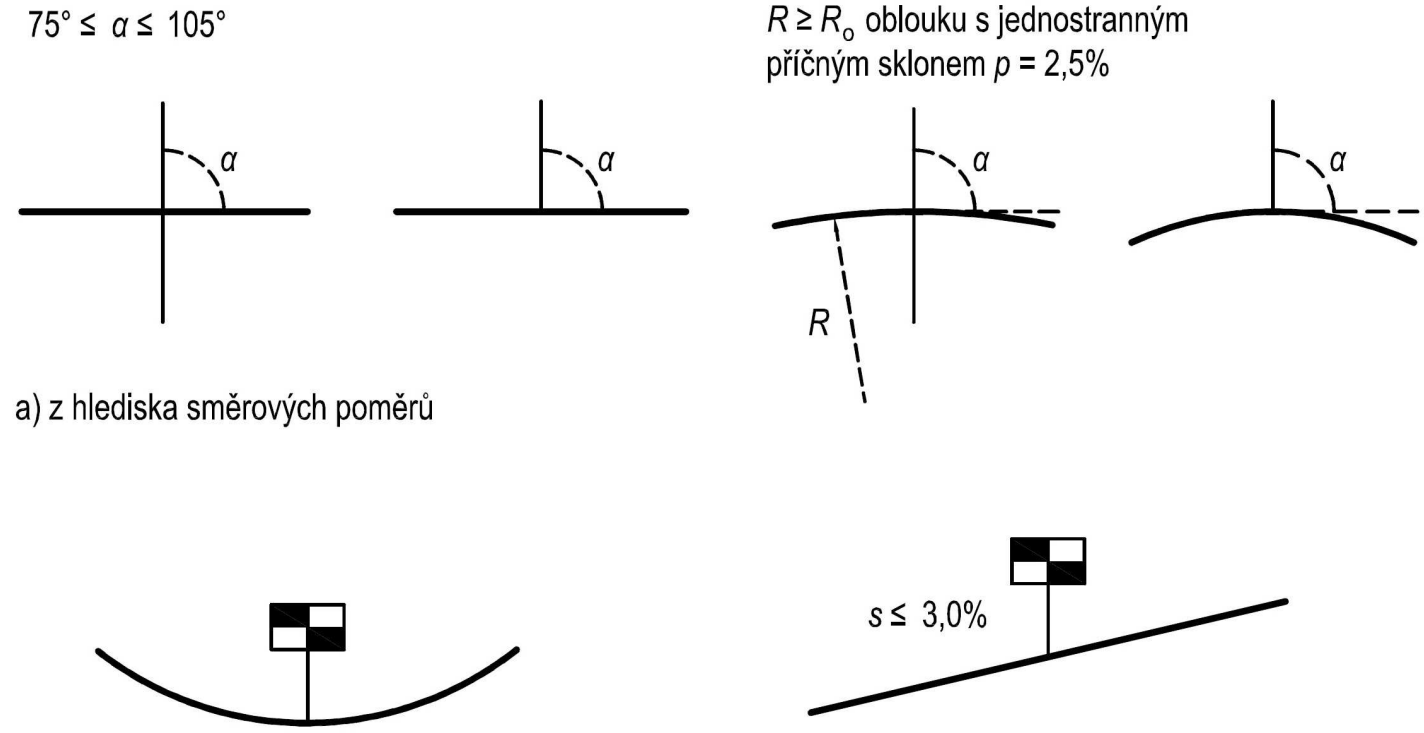


fig. 0540 (appropriate location of at-grade junction)

- essential criterion and aspect of junction design = road safety ⇒ human factor must be taken into account
- at-grade junctions must always have one road indicated as major road and other as minor

ELEMENTS OF JUNCTION

Basic geometric elements of junction (*fig. 0550*):

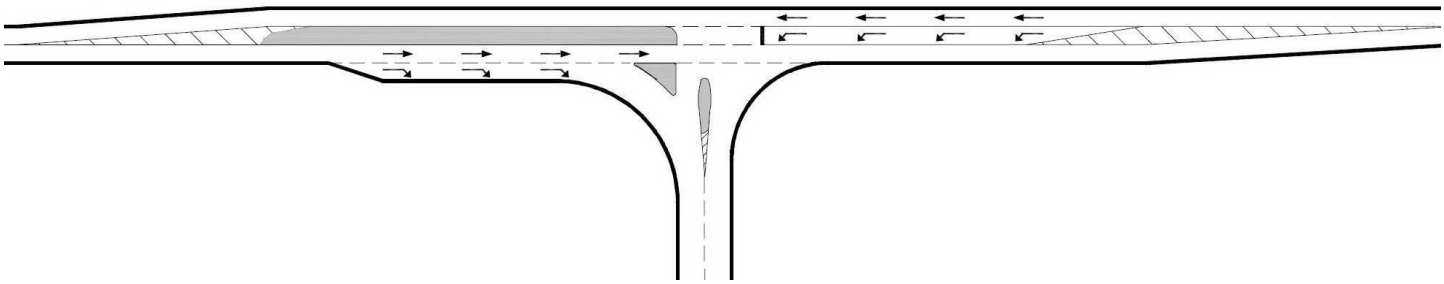


fig. 0550 (T-junction with all elements except a merge lane)

- *mainline*
- *auxiliary lanes* (*even in a shortened version*)
  - *diverge lane (for turning)*
  - *merge lane (for connecting)*
- *traffic islands* (*can be substituted by ghost islands*)
- *central reservation, green belts and other divisions*
- *junction corners*
- *slip roads (and other connectors)*

Mainline

- **basic lane width** in straight at junctions = width outside of an junction (on major or minor road)
- determine **basic elements of typical cross-section** for both **intersecting roads** according to their categories (see the assignment) according to *fig. 0560* and *fig. 0570*

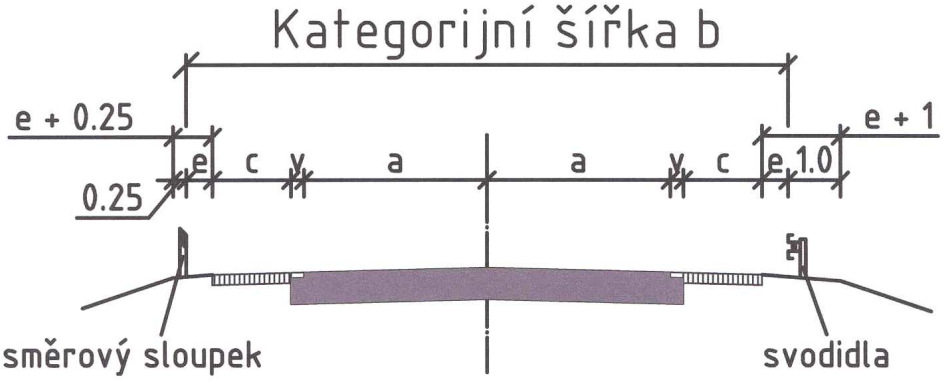


fig. 0560 (typical cross-section of two-lane roads)

Návrhová kategorie			Šířka v m			
písmenný znak	b m	návrhová rychlost km/h	a*)	v	c	e
S	6,5**)	60; 50	2,75	0,00	0,00	0,50
S	7,5	70; 60; 50	3,00	0,25	0,00	0,50
S	9,5	80; 70; 60	3,50	0,25	0,50	0,50
S	11,5	90; 80; 70	3,50	0,25	1,50	0,50
*) Základní hodnota bez rozšíření ve směrovém oblouku. **) Navrhuje se při intenzitě silničního provozu do 1000 voz /24 h.						

fig. 0570 (basic elements of typical cross-section of two-lane roads)

- need to **reduce the speed** of vehicles in mainline because of road safety ⇒ **narrowing** its width **by 0,25m**

Auxiliary lanes

- basic **width of auxiliary lanes „a_p“** - *fig. 0580*

Pozemní komunikace	Základní šířka a_p v m	Šířka ve zdůvodněných případech v m
Kategorijní typ silnice:		
S 24,5	3,50	3,25 (3,00) ve stísněných podmínkách
S 20,75	3,25	3,00
S 11,5	3,25	3,00
S 9,5	3,25	3,00 (2,75) ve stísněných podmínkách
S 7,5	3,00	3,00 (2,75) ve stísněných podmínkách

fig. 0580 (basic widths of auxiliary lanes on roads)

Diverge lane:

- it refers to T-junction models:
  - ***SÚK V*** *.....left turn from major road (**flow 7**)*
  - ***SÚK VI*** *.....left and right turn from major road (**flows 3 and 7**)*
- It consists of **three sections** (*fig. 0590*):
  - *length* ***L_v*** *.....**diverge** section (**taper**)*

- *length **L_d**.....**decelerating** section*
- *length **L_c**.....**waiting** section*

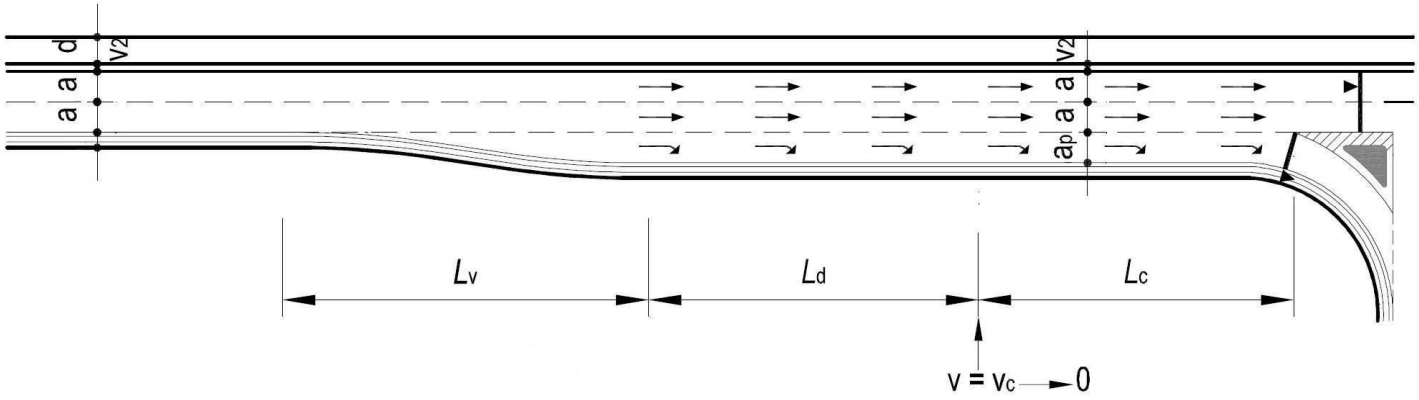


fig. 0590 (sections of auxiliary lane for right turn with stopping)

- length of each sections are based on speeds and other variables:
  - ***v_n***.....***design speed on the** (major or minor) **road** – determine according to fig. 0020 and the values from the assignment:*
    - rows ..... given value of design category
    - columns..... terrain classification based on map data
    - **v_n [km/h]**....value in the upper part of intersection of selected row and column
  - *v = **0,75•v_n**...speed **at the end** of diverge section (**L_v**)*
  - ***v_k***.....*design speed **in horizontal curve** of junction **slip road** – **set** for slip roads **AC** (based on knowledge of **v_n on major** road) and **CB** (based on knowledge of **v_n on minor** road) according to fig. 0600)*

Kategorijní typ			Návrhová rychlost v km/h	Návrhová rychlost směrových oblouků křižovatky v_k v km/h						
				15	20	25	30	35	40	50
S 4,5			30	■	●					
			40	■	●					
S 6,5	S 7,5		50		■	●				
		S 9,5	60		■	●				
S 11,5			70			■	●			
			80			■	●			
			90				■	●		

Legenda

● Výjezd z hlavní komunikace na vedlejší komunikaci.
■ Vjezd na hlavní komunikaci z vedlejší komunikace.

fig. 0600 (design speeds „v_k“ for slip roads from at-grade junction)

- ***v_c*** *.....speed **at the end** of decelerating section (**L_d**)*
  - left turn (flow 7) .....$v_c = 0$
  - right turn (flow 3) .....$v_c = v_k$
- ***ppv [%]*** *.....percentage of slow vehicles ⇒ take the same as on the major road*
- ***d = 1,7 m/s²*** *..average deceleration*
- ***s*** *.....longitudinal gradient of the section in percentage (**BEWARE OF DRIVING DIRECTION – respect the sign !!!**)*
- ***d' = a_p*** *.....required **cross displacement** [m]*
- ***P_v [voz]*** *.....number of all **vehicles waiting for turning** ⇒ determine from the curves in the graph in fig. 0610 according to the combination of traffic volumes of each traffic flows*

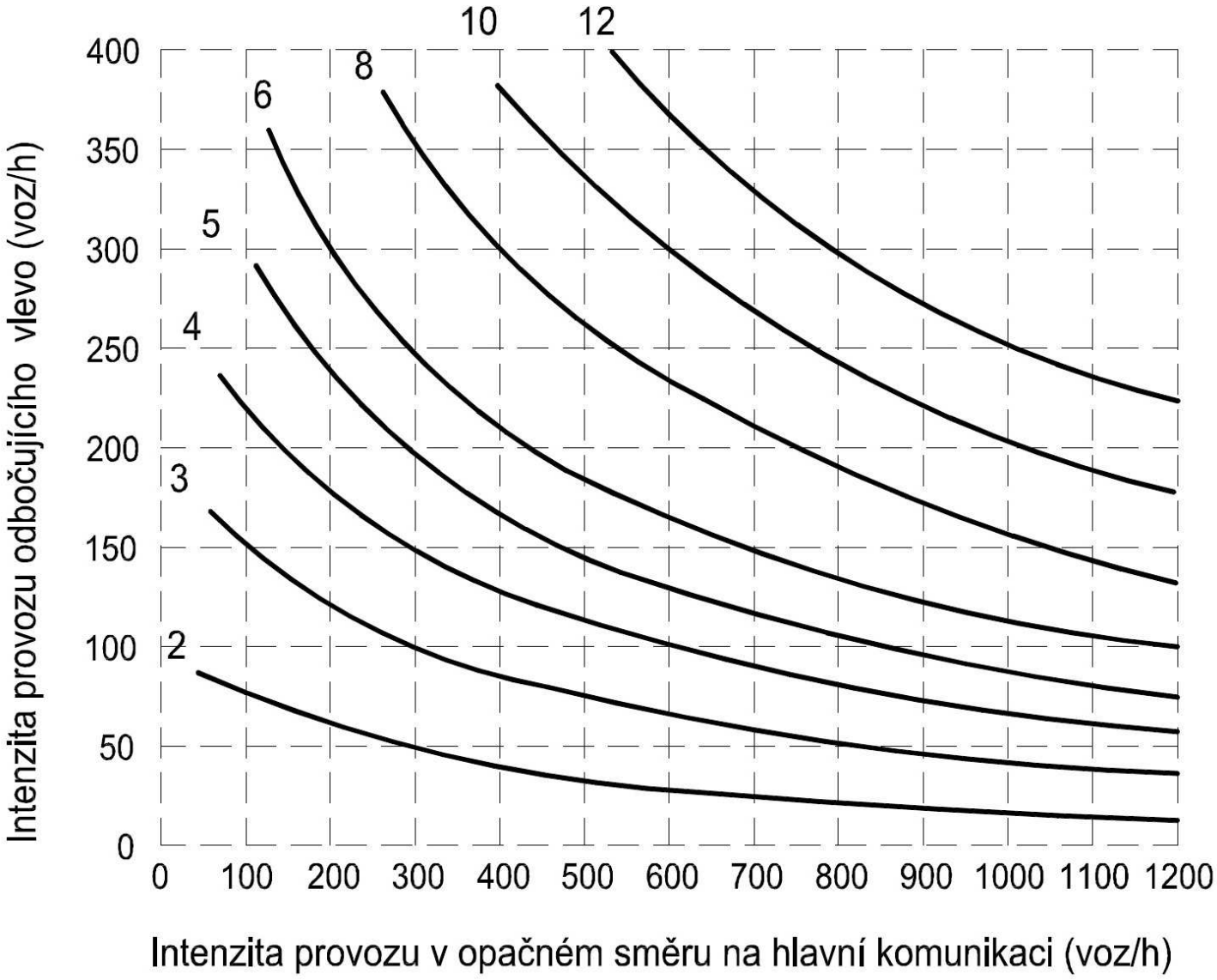


fig. 0610 (graph to determine P_v)

- **Lengths of the three sections**:

a) Diverge section (L_v):

- ***Determine for** all turn lanes (if they exists ⇒ for flows **3 and 7**) according to „v_n“ and „a_p“ of the major road - fig. 0620*

Šířka odbočovacího pruhu v m	Návrhová rychlost v km/h						
	50	60	70	80	90	100	120
3,5 (3,25)	40	45	55	60	70	80	100
3,0 (2,75)	35	40	50	55	65	75	–
Délka vyřazovacího úseku pro šířky odbočovacích pruhů užších než 2,75 m se určí z poměru šířky k délce 1:10. Zvýrazněné hodnoty v tabulce platí zejména pro navrhování mimoúrovňových křižovatek.							

fig. 0620 (length of diverge sections „L_v“)

- *The **taper** for **d‘ = a_p** is carried out **on the length L_v** merge lane **3** (fig. 0630)*

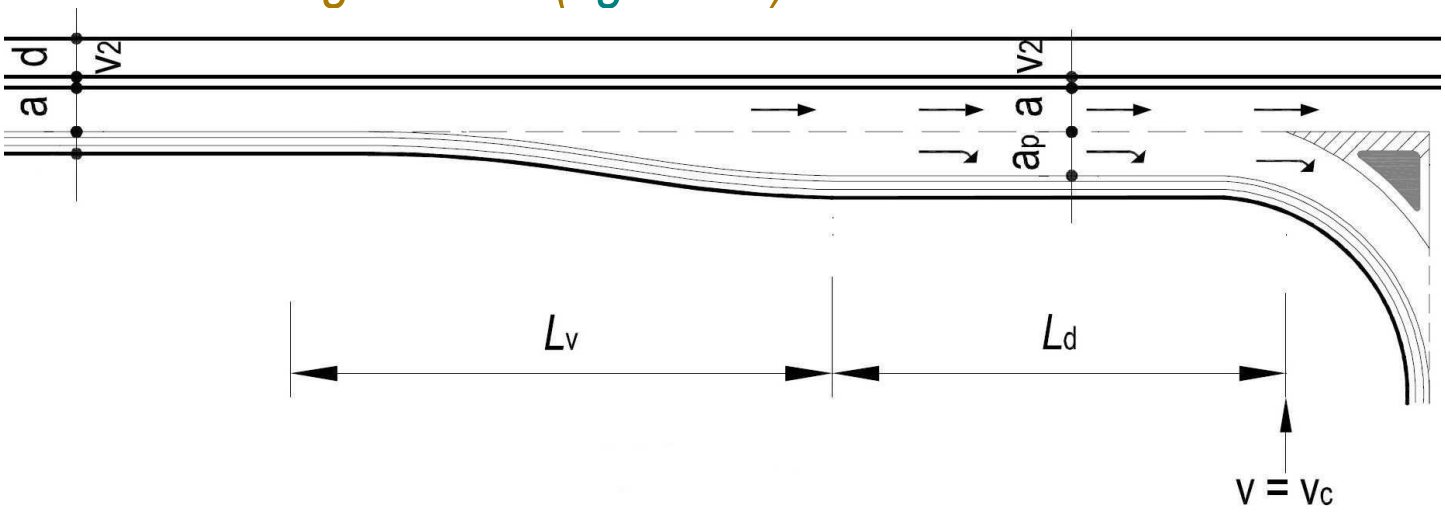


fig. 0630 (dimension L_v at turn lane for flow 3)

b) Decelerating section (L_d):

- *Calculate using the following **formula** (**for** all turn lanes, if they exists – for flows **3 and 7**) – **BEWARE OF DRIVING DIRECTION – check the sign in front of „s“!***

$$L_d = \frac{(0{,}75 \bullet v_n)^2 - v_c^2}{26 \bullet \left(d + \frac{s}{10}\right)}$$

c) Waiting section (L_c):

- *Calculate using **formula** (**only for** the left turn lane – for flow **7**) – length of waiting section L_c is not used for turn lane without stopping (fig. 0630)*

$$L_c = P_v \bullet \left(6 + \frac{8 \bullet ppv}{100}\right)$$

- *The beginning of length L_c is at the stopping point (e.g. stop line) – se fig. 0640*

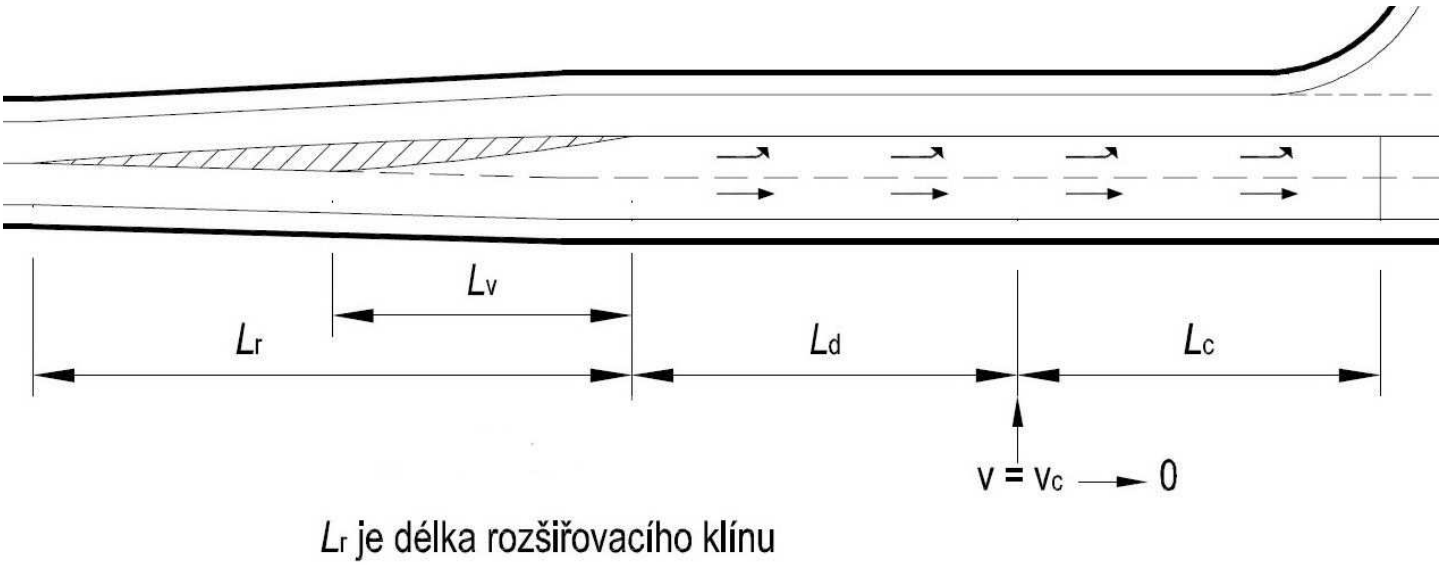


fig. 0640 (dimension of L_c at lane for flow 7)

- Length of **the ghost island „L_r“**:
  - *Calculate using the following formula in case of **the major road**:*

$$L_r = v_n \bullet \sqrt{d'}$$

  - ***Length L_r** is used for left turn lane (flow 7) to construct **the ghost island** – see fig. 0640*
  - ***Ghost** island at the opposite side is also made in **length L_r** (fig. 0650)*

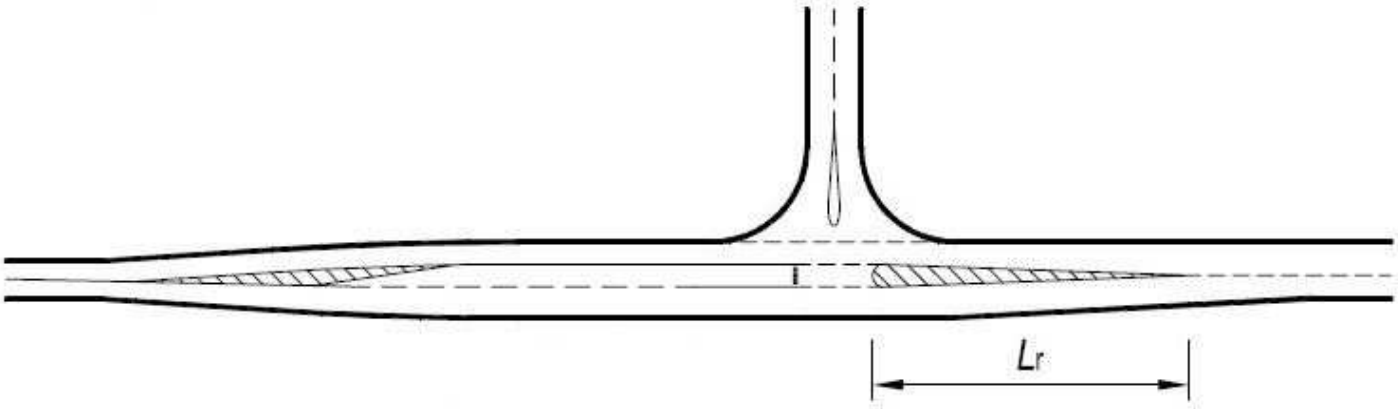


fig. 0650 (use of length L_r at the junction exit)

- ***Starting points of sections L_c and L_r** are **tangent points** of **left turn** radii edges (fig. 0660)*

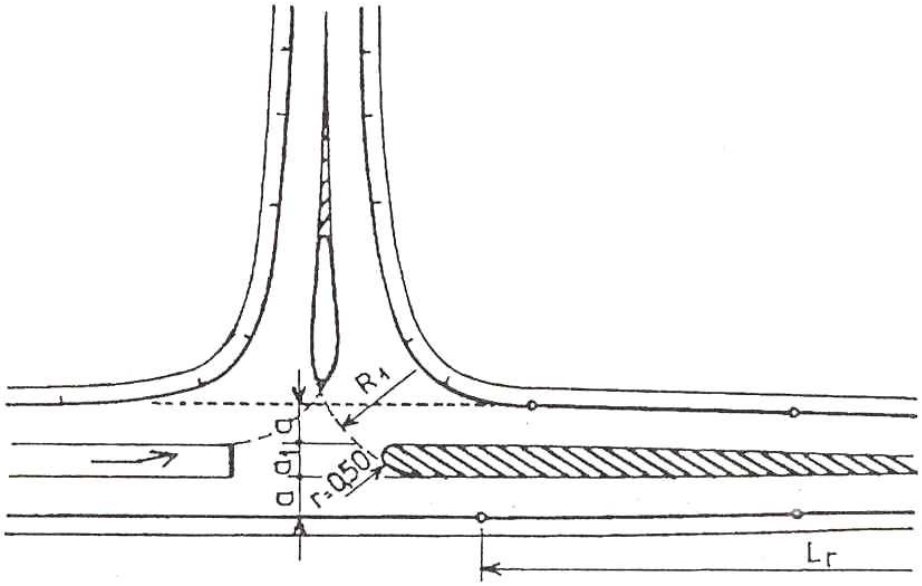


fig. 0660 (starting points of sections L_c and L_r)

Merge lane:

- **concerns** these T-junctions:
  - ***SÚK VI*** *.....right turn off the minor road (**flow 6**)*
- Consists of **3 sections** (see *fig. 0670* and *fig. 0672*):
  - *length **L_a** ..... **accelerating** section (for $v_n \leq 80$ km/h)* or
  - *length **L_{od}** ... **separating** section (for $v_n > 80$ km/h)* +
  - *length **L_m** .... **manoeuvring** section*
  - *length **L_z** ..... **merging** section (**taper**)*

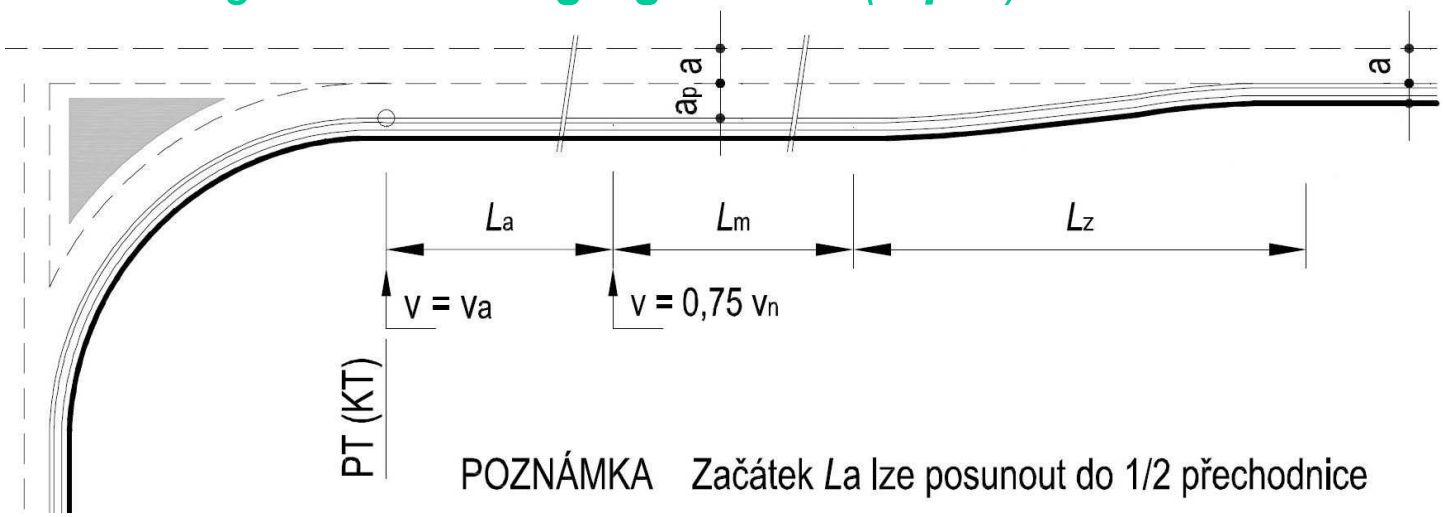


fig. 0670 (sections of merge lane for $v_n \leq 80$ km/h)

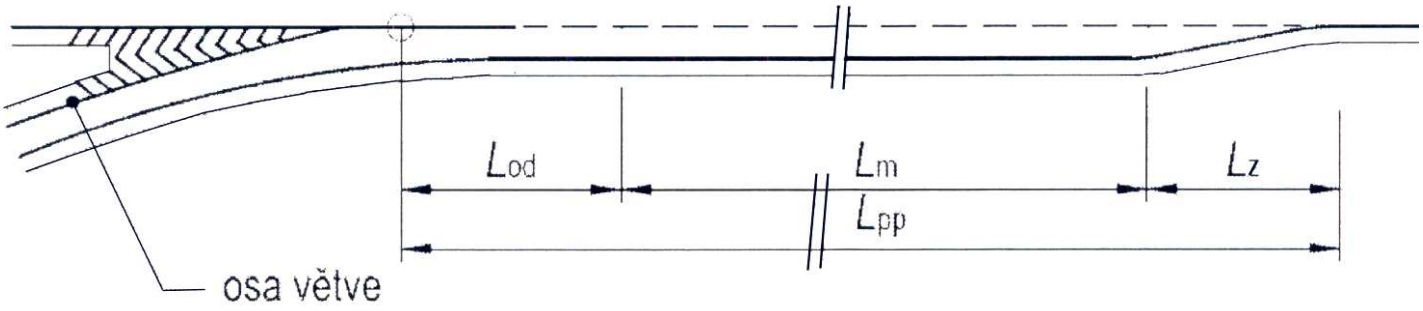


fig. 0672 (sections of merge lane for v_n > 80 km/h)

- each sections lengths are based on **speed and** other **variables**:
  - ***v_n*** *.....* ***major road design speed*** *– determine according to fig. 0020 on the basis of entering values:*
    - rows .....entering value of design category
    - columns.... terrain classification based on map data
    - **v_n [km/h]** ....value in the upper part of intersection of selected row and column
  - *v =* ***0,75•v_n*** *... speed* ***at the end*** *of accelerating section (**L_a**)*
  - ***v_k*** *..... design speed* ***in horizontal curve*** *of junction* ***slip road CB***
  - ***a = 1,2 m/s²*** *.. average acceleration*
  - ***s*** *..... longitudinal slope of the section in percentage (**BEWARE OF DRIVING DIRECTION – respect the sign !!!**)*
- **length of 3 sections** for $v_n \leq 80$ km/h (for all two-lane road categories **with exceptions of S 11,5 / 90**)

a) accelerating section (L_a):

- *calculate* ***using formula*** *(****only for*** *merge lane flow* ***6****) – see fig. 0630*

$$L_a = \frac{(0{,}75 \bullet v_n)^2 - v_k^2}{26 \bullet \left(a - \frac{s}{10}\right)}$$

$L_a \leq 120$ m

b) manoeuvring section (L_m):

- ***determine for*** *merge lane flow* ***6*** *according to „v_n“ of major road according to fig. 0680*

Návrhová rychlost v_n v km/h	50	60	70	80
Délka manévrovacího úseku L_m v m	75	85	100	115

fig. 0680 (lengths of manoeuvring sections „L_m“ for $v_n \leq 80$ km/h)

c) merging section (L_z):

- ***determine for*** *merge lane flow* ***6*** *according to „v_n“ and „a_p“ of the major road according to fig. 0690*

Šířka připojovacího pruhu v m	Rychlost v km/h			
	50	60	70	80
3,5 (3,25)	40		50	
3,0 (2,75)	30		40	
Délka zařazovacího úseku pro šířky připojovacích pruhů užších než 2,75 m se určí z poměru šířky k délce 1:10.				

fig. 0690 (lengths of merge sections „L_z“ for $v_n \leq 80$ km/h)

- **lengths of 3 sections** for $v_n > 80$ km/h (use **only for** road category **S 11,5 / 90**) – **determine for** merge lane

of flow **6** according to „v_n“ of the major road according to *fig. 0694*

Návrhová rychlost v km/h	90	100	120
Délka oddělovacího úseku L_{od} v m *)	30	30	30
Délka manévrovacího úseku v L_m v m	130	145	175
Délka zařazovacího úseku L_z v m	70	80	90
Délka připojovacího pruhu v m (L_z + L_m + L_{od})	**230**	**255**	**295**
*) Začátek oddělovacího úseku není shodný se začátkem podélné čáry souvislé.			

fig. 0694 (lengths of separating, manoeuvring and merging sections „L_{od}“, „L_m“ and „L_z“ for v_n > 80 km/h)

Traffic islands and ghost islands

- traffic islands and ghost islands are used to separate and regulate various traffic flows

Traffic islands (see *fig. 0700*)**:**

- implementation ⇒ **raised and impassable** (usually lined with **kerbing**)
- large islands ⇒ **unpaved** (with vegetation arrangement and without kerbing)

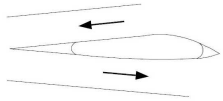
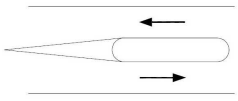
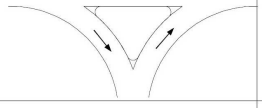
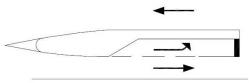
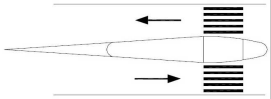
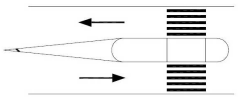
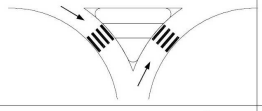
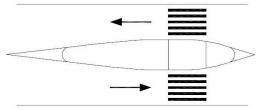
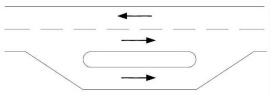
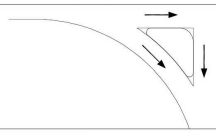
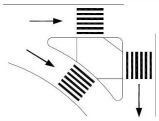
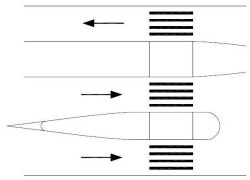
Druh	Funkce	Tvar (schéma)			
		Kapkovitý	Obdélníkový se (zaoblením)	Trojúhelníkový	Složený
Dělicí ostrůvek	Dělicí				
	Dělicí a ochranná				
Směrovací ostrůvek	Směrovací		 postranní		
	Směrovací a ochranná				
Ochranný ostrůvek	Ochranná				

fig. 0700 (traffic islands)

Ghost islands:

- **traffic islands** are marked only by **road marking**
- they are always used at **single carriageway major roads** (use for mainline AB in the exercise)
- possibility of adding **reflective elements** (reflecting road studs,… etc.)
- **edges** of ghost islands define **edges of traffic lanes**

CALCULATION OF ALIGNING ELEMENTS OF INNER CURVES „CA“ AND „BC“ FOR LEFT TURN

Teardrop traffic island

- it is being established at the approach of minor road
- shape – type A (is used for the exercise – *fig. 0710*) and type B (need to slow down the entry on major road)

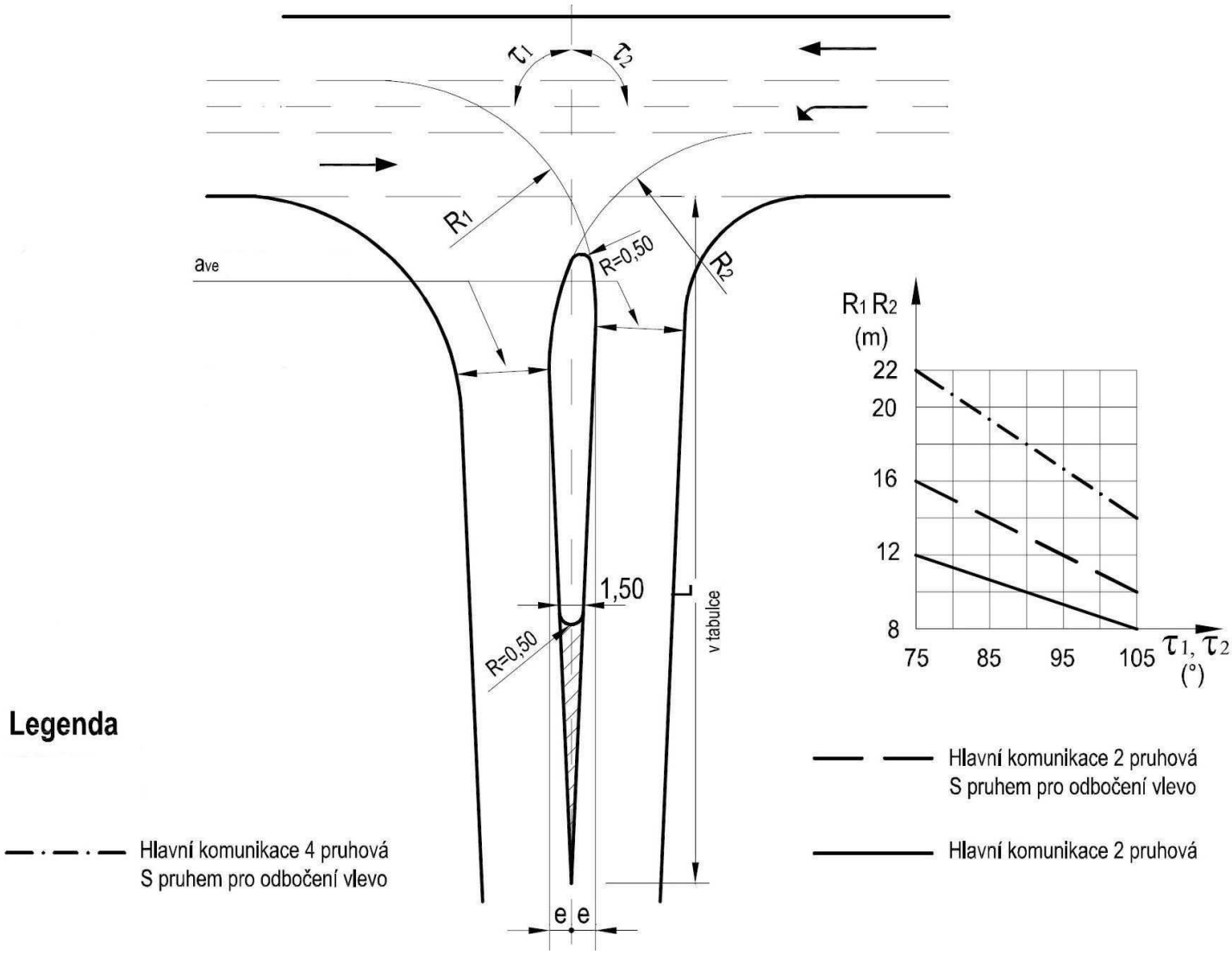


fig. 0710 (teardrop traffic island of type A – basic dimensions)

Determining (calculating) the necessary values

- converting **angle values** (in accordance with *fig. 0710*):
  - *central angle of the curve CA ..... $\tau_1 = \tau_{CA} = 180° - \alpha$*
  - *central angle of the curve BC ..... $\tau_2 = \tau_{BC} = \alpha$*
- determining **the eccentricity of traffic island „e“** (according to *fig. 0720*) by τ_1

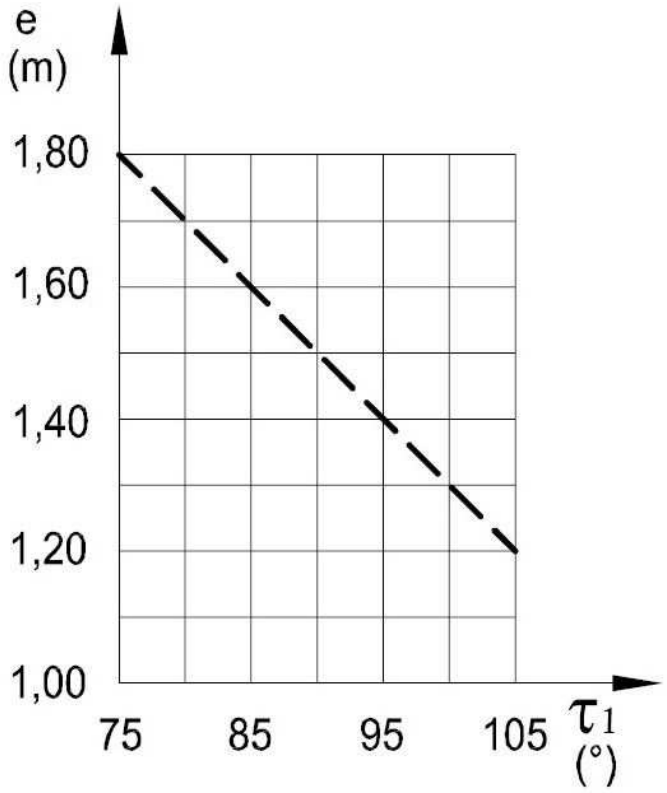


fig. 0720 (determining the eccentricity of traffic island)

- determining **the length of traffic island „L“** (according to *fig. 0730*) by major road arrangement:

	Charakteristika hlavní komunikace		
	dvoupruhová	dvoupruhová s pruhem pro odbočení vlevo	čtyřpruhová s pruhem pro odbočení vlevo
R ($\tau = 90°$)	10,00 m	13,00 m	18,00 m
L	20,00 m	40,00 m	40,00 m
a	šířka jízdních pruhů podle návrhové kategorie nebo typu příčného uspořádání		
$\Delta a + a$	rozšířený jízdní pruh v oblouku		
b_0	odsazení dopravního ostrůvku od okraje jízdního pruhu		

fig. 0730 (recommended values for type A teardrop traffic island construction)

- *for **SÚK III** and **SÚK IV**.....L = **20** m*
- *for **SÚK V** and **SÚK VI**.....L = **40** m*

- determine **the** inner curves **radii $R_1 = R_{CA}$** and **$R_2 = R_{BC}$** out of *fig. 0710*:
  - $\tau_1 \Rightarrow R_1 = R_{CA}$
  - $\tau_2 \Rightarrow R_2 = R_{BC}$

- *SÚK III ⇒ solid lane*
- *SÚK IV ⇒ solid lane*
- *SÚK V ⇒ broken line*
- *SÚK VI ⇒ broken line*

❖ Left turning **curves tangents CA** and **BC** (in accordance with *fig. 0710*):

$$T_{CA} = R_{CA} \bullet \operatorname{tg}\frac{\tau_1}{2} \qquad T_{BC} = R_{BC} \bullet \operatorname{tg}\frac{\tau_2}{2}$$

❖ determine **traffic lanes widths** on the basis of value „a“ of road typical cross-section according to *fig. 0560* and *fig. 0570*:

- $a_H = a$ .... *for major road (in the direction AB)*
- $a_V = a$ ..... *for minor road (in the direction CX)*

❖ determine the final **width of enveloping curves** of traffic lanes $a_{ve(CA)} = \mathbf{a_{CA}'}$ and $a_{ve(BC)} = \mathbf{a_{BC}'}$ (for left turn „CA“ and „BC“ – see *fig. 0710*) by extending Δa_{CA} and Δa_{BC} (determine out of the following table using values R_{CA} and R_{BC})

R	[m]	8	9	10	11	12	13	14	15	16
Δa	[m]	4,60	4,10	3,75	3,50	3,30	3,10	2,95	2,80	2,65

$$a_{ve(CA)} = a_{CA}' = a_v + \Delta a_{CA} \qquad a_{ve(BC)} = a_{BC}' = a_v + \Delta a_{BC}$$