CLASIFICATION OF ROADS AND MOTORWAYS

$k_{V,P}$ .... growth rate of passenger traffic
$k_{V,F}$ .... growth rate of freight traffic
T_V, $k_{V,P}$, $k_{V,F}$...... consider for decommission (2045)

$$\boxed{T_V^{50} = \left(T_{V,P}^{X \to Y} + T_{V,P}^{Y \to X}\right) \bullet k_{V,P} + \left(T_{V,F}^{X \to Y} + T_{V,F}^{Y \to X}\right) \bullet k_{V,F}}$$

- Conversion to all-day traffic volume T_V:
  - *First-class roads* .... $T_V = \dfrac{T_V^{50}}{0,101}$
  - *Second-class roads and third-class roads*.... $T_V = \dfrac{T_V^{50}}{0,122}$
- T_V is also referred as AADT (Annual Average Daily Traffic)
- according to TP 189 is a 50 times a year occurring hourly traffic volume (on roads with mixed traffic pattern):
  - *10,1 % of all-day traffic volume – first-class roads*
  - *12,2 % of all-day traffic volume – second-class roads and third-class roads*
- $[T_V^{50}]$ = vehicles/hour
- $[T_V]$ = vehicles/24hours

classification of the terrain (according to the topographical map in background – MP)

1. MP $\in \{10; 11; 12; 13\} \to$ level, gently rolling terrain
2. MP $\in \{1; 4; 5; 8; 9\} \to$ rolling terrain
3. MP $\in \{2; 3; 6; 7\} \to$ mountainous terrain

DETERMINATION OF ROADS CATEGORY

(according to *fig. 0010*):

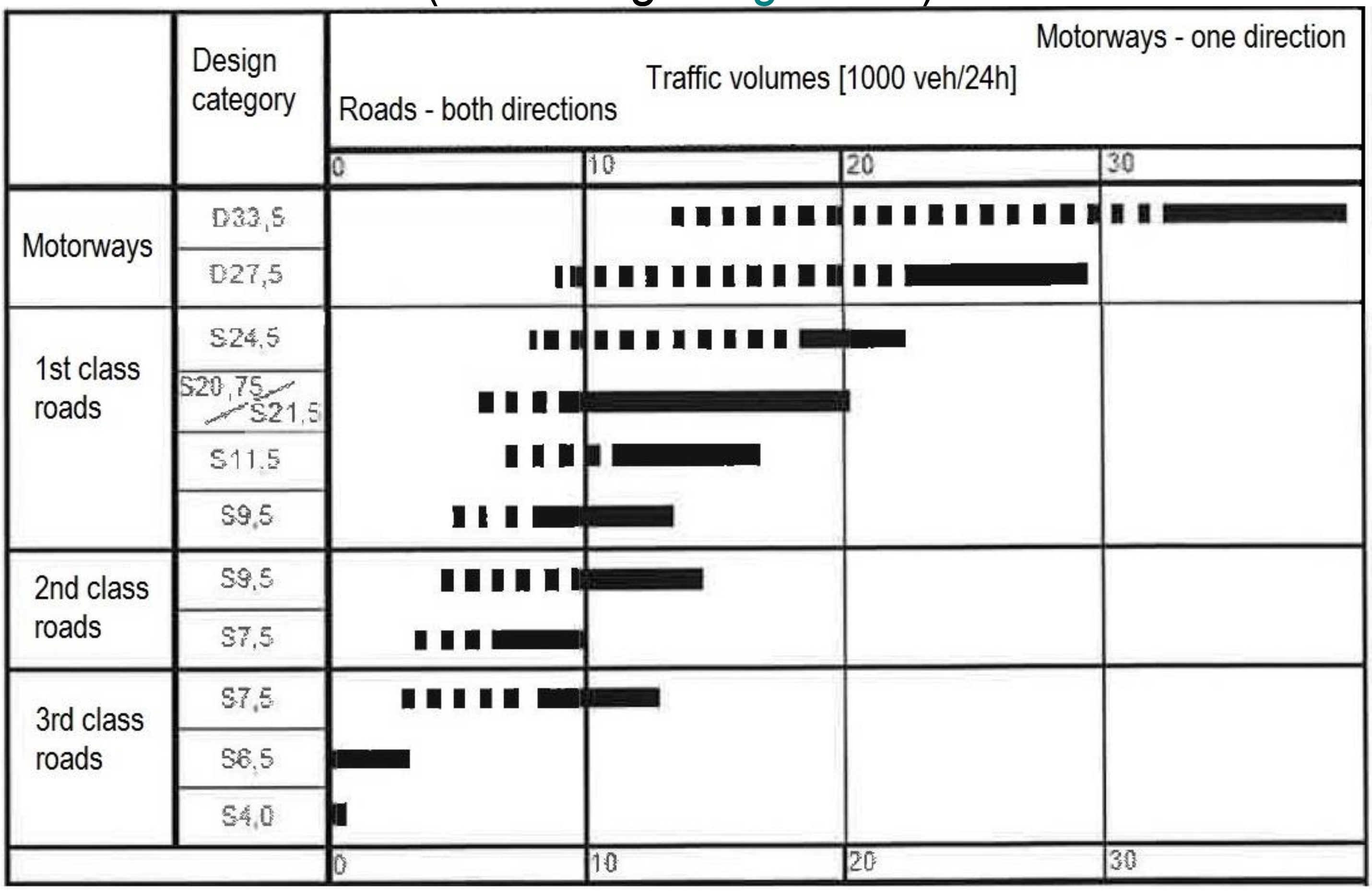

fig. 0010 (preliminary determination of the design category of road)

Procedure:

- according to the value T_V [vehicle/day] identify the design category in *fig. 0010*
- consider only 2 lane roads (category S 11,5 and below)
- select category according to the following priorities:
  - ***within the class road** given in assignment*
  - *according to the line segment in which the value **T_V intersects** section highlighted **solid** line **the closest** to its **centre***

- *the value* ***T_V intersects*** *no* ***solid*** *line → choose category according to the line segment in which the value* ***T_V intersects*** *section highlighted by a* ***dotted*** *line* ***and also closest*** *to the start position indicated by a* ***solid*** *line*
- *the value* ***T_V intersects no*** *segment of a line → choose the category by a line whose* ***end*** *is closest the value* ***T_V***

<u>the choice of a design speed</u> – „V“ → according to *fig. 0020*:

- *rows* – *known value of a* *design category*
- *columns* – *known* *terrain classification*
- ***V [km/h]*** = *value at the top of the* *intersection* *specified row and column*

Design category of road or motorway	Design speed for respective terrain [km/h]			
	level terrain	rolling terrain	mountainnous terrain	
	longitudinal gradient [%]			
D 33,5	120	120	100	80
D 27,5	3	4	4,5	4,5
S 25,5	120	100	80	
	3,5	4,5	5	
S 21,5	100	100	80	
	3,5	4,5	6	
S 24,5	100	80	70	
	3,5	4,5	6	
S 20,75	90	80	70	
	4	4,5	6	
S 11,5	90	80	70	
	4,5	6	7,5	
S 9,5	80	70	60	
	4,5	6	8	
S 7,5	70	60	50	
	4,5	7	9	
S 6,5	60	60	50	
	7	8	9	
S 4,0	40	40	30	
	10	11	12	

fig. 0020 (values V and G_{max})

Record the values (in the technical report):

- *terrain classification............by the map (see above)*
- *design traffic volumes..........T_V [vehicle/day]*
- *road class ....as of the assignment*
- *design category ....according to the second column in fig. 0010*
- *V [km/h] ....design speed fig. 0020*
- *S_{max} [%] ....max. superelevation fig. 0030*
- *S_0 [%]..................................crossfall of normal crown*

According to the knowledge of category and the design speed determine the **minimum horizontal curve radius R_{min}** – 2 options (depending on the crossfall and design speed):

❖ according to *fig. 0030* ⇒ S_{max} should be in the project chosen from the interval ⟨2,5%; 6%⟩

Design speed V [km/h]	Radii of horizontal curves R_{min} [m]										
	Maximum superelevation S_{max} [%]										Crossfall of normal crown S_0 [%]
	2,5	3	3,5	4	4,5	5	5,5	6	6,5	7	
130	2450	2050	1750	1225	1350	1225	1125	1025	-	-	4500
120	2075	1750	1500	1300	1150	1050	950	850	-	-	3800
110	1750	1450	1250	1100	975	875	800	725	-	-	3200
100	1450	1200	1050	900	800	720	650	600	-	-	2700
90	1200	1000	850	750	650	600	550	500	-	-	2200
80	775	650	550	500	450	400	350	325	-	-	1700
70	600	500	425	375	330	300	270	250	-	-	1300
60	450	375	325	270	240	220	200	180	170	-	950
50	300	250	220	190	170	150	140	125	120	110	700
40	200	160	140	120	110	100	90	80	75	70	450
30	110	90	80	70	60	55	50	45	40	35	250

fig. 0030 (values of R_{min} depending on V and S_{max} or S_o)

❖ use the following formula:

- $V \leq 80$ km/h: $$R \geq R_{min} = \frac{0{,}3 \bullet V^2}{S_{max}}$$
- $V > 80$ km/h: $$R \geq R_{min} = \frac{0{,}36 \bullet V^2}{S_{max}}$$

DRAFT OF HORIZONTAL ALIGNMENT – 2 VARIANTS:

1. generous (red)
   - the lowest operating costs ⇒ no need to respect the terrain, large earthworks can be used
   - little (maximum 5) horizontal curves
   - larger radii of horizontal (R) curves (about 3 times the minimum value)
   - it is possible to use bridges
   - it is possible to use tunnels (only in mountainous terrain and under the conditions specified below)

2. economical (green or blue)
   - the lowest construction costs ⇒ the attempt to respect the terrain (avoid large earthworks)
   - more (over 5) horizontal curves
   - minimum radii (R) of horizontal curves can be used (of course larger radii can be used if there is no need to use the minimum ones)

PLAN

- chainage of points A, TCi, CTi a B in “km” to 5 decimal places – *fig. 0040* (also specify the chainage of points A and B at the beginning and end of the route – *fig. 0050*)
- tables of horizontal curves including:
  - radius of curve in “m“ to 2 decimal places
  - deflection angle of curve in “°“ to 5 decimal places
  - length of curve in “m“ to 2 decimal places
  - tangent of curve in “m“ to 2 decimal places
- tables of objects (tables of bridges, culverts or tunnels)
  - number of the object (each type of object has its own numerical series)
  - name of the object type
  - chainage of the beginning and end of the object in “km” to 5 decimal places (only on chainage for culverts)

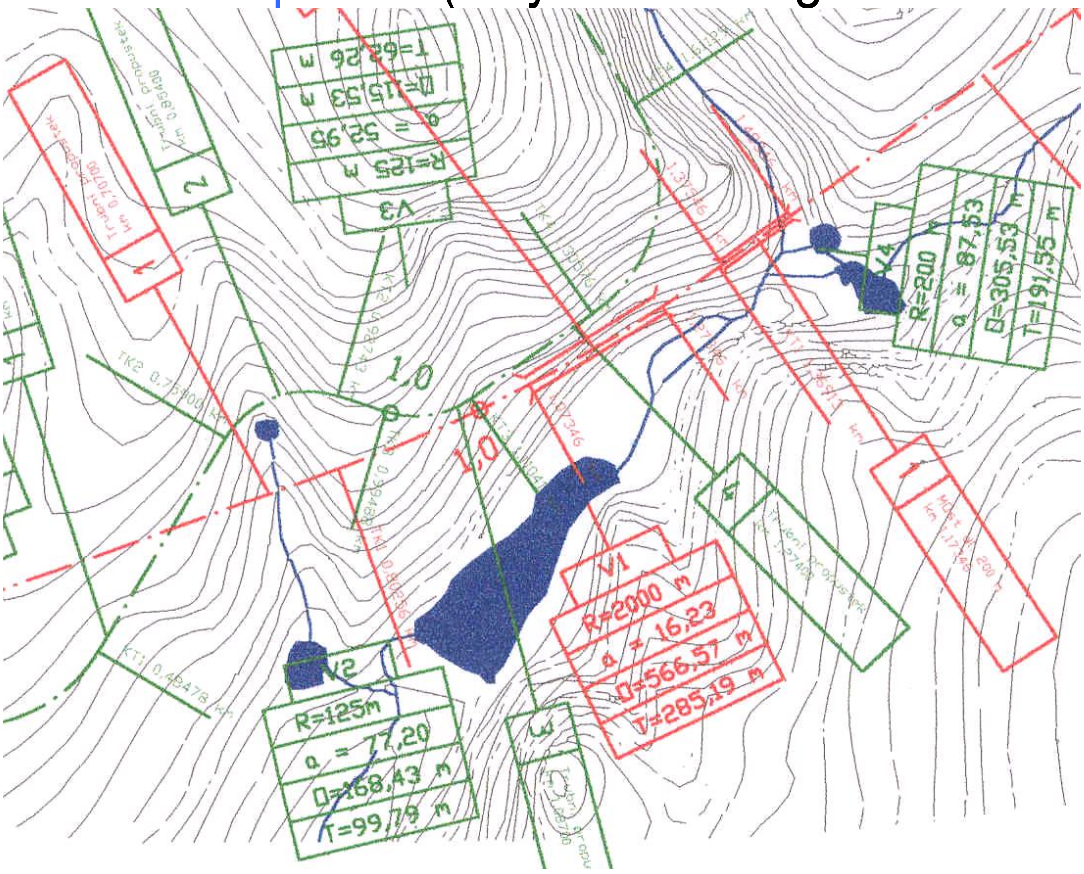

fig. 0040 (plan – chainage and tables of objects)

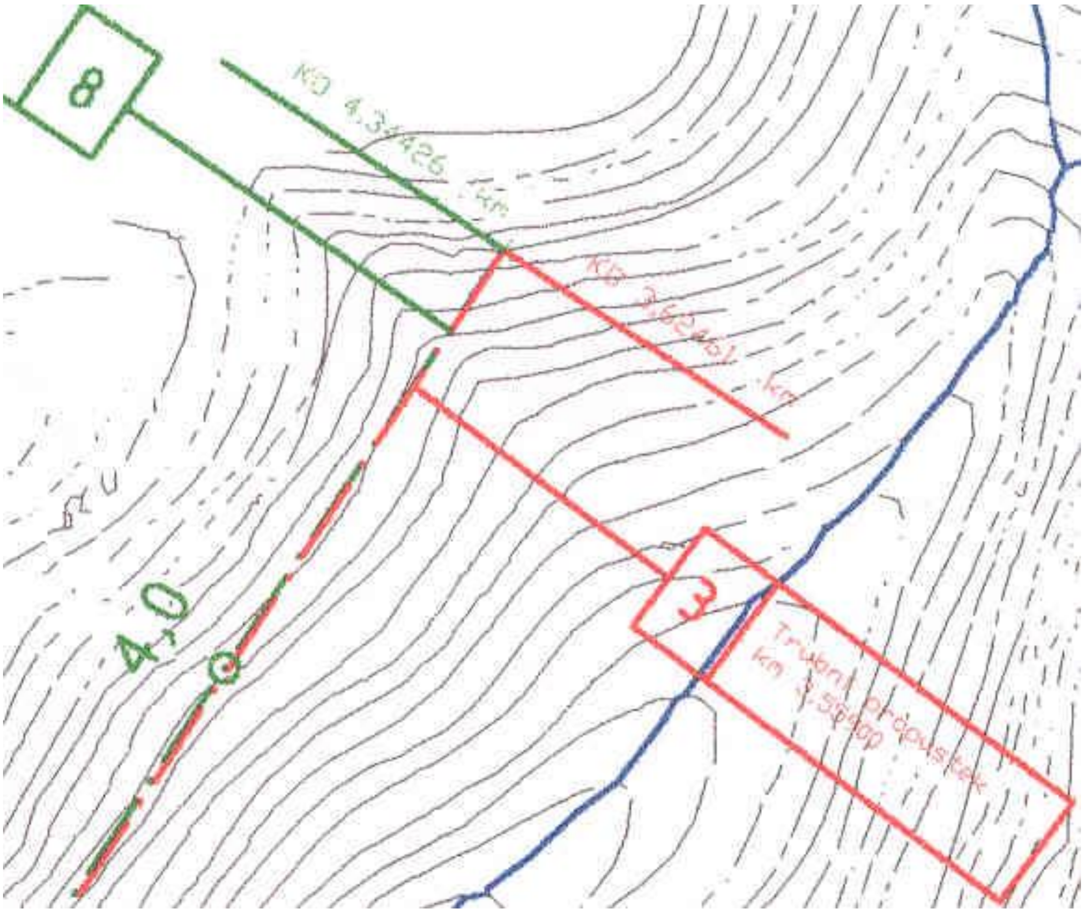

fig. 0050 (plan – chainages in point B)

Simplified horizontal alignment (no transition curves)

(*fig. 0070*)

- I........ central angle of horizontal curves – see *fig. 0060*

- tangent of horizontal curve: $\boxed{T = R \bullet tg\left(\frac{I}{2}\right)}$

- length of horizontal curve: $\boxed{L_C = R \bullet arcI = \frac{R \bullet I \bullet \pi}{180}}$

- [I] = °
- [L_C] = m
- [R] = m

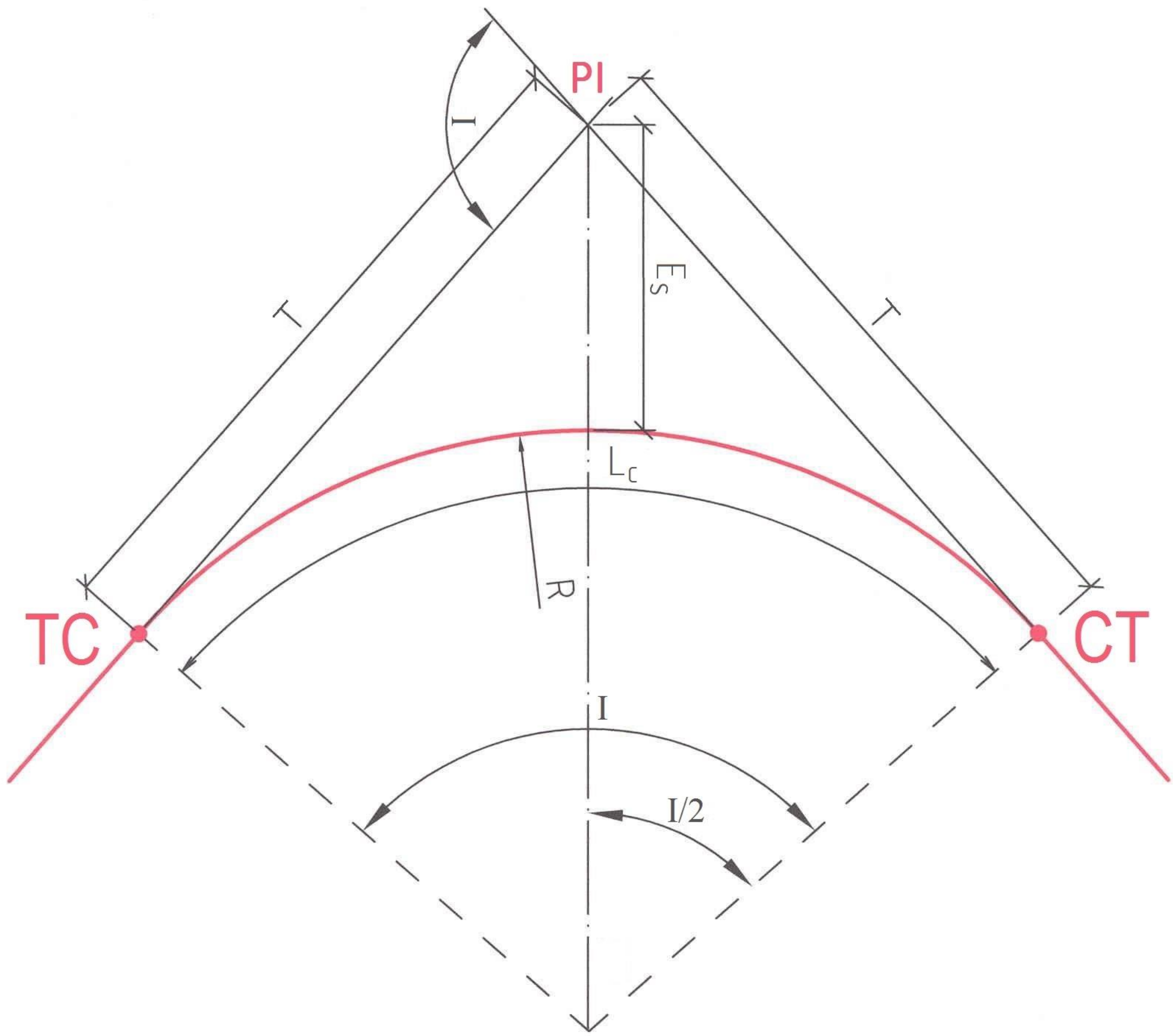

fig. 0060 (simple circular curve without transition curves)

- to decide the chainage of points TC_i and CT_i

  ⇒ measure the distance from the beginning of the route (point A) to the point TC_1

  ⇒ measure the distance of each straight section between points CT_i and TC_{i+1}

  ⇒ calculate the length of each horizontal curve between points TC_i and CT_i

  ⇒ measure the distance from the last point CT_i to the end of the route (point B)

- the straight sections should be long enough, so the transition curves can be inserted there later, thus:
  ⇒ the distance from the beginning of the route (point A) to the point TC_1 [m] $\cong$ 1•V [km/h]
  ⇒ the length of each straight section between points CT_i and TC_{i+1} [m] $\cong$ 2•V [km/h]
  ⇒ the distance from the last point CT_i and the end of the route (point B) [m] $\cong$ 1•V [km/h]

fig. 0070 (plan – an example of the overall solution)

- record values of the chainage points TC_i and CT_i into the technical report
- tables of horizontal curves contain – number of the horizontal curve, R, I, L, T (see *fig. 0040*)
- the numbering of horizontal curves (and object) increases along with the chainage
- the extension lines of the chainage as well as the extension lines of the tables of horizontal curves should be drawn perpendicularly to the road centreline
- the brightness of the contour line colours should be suppress before printing of the plan drawing

Selecting a curve radius, depending on the length of previous straight section:

- the radius R_i of the horizontal curve „i" depending on the length of the adjacent straight section (tangent) should not be "inappropriate" according to *fig. 0080*

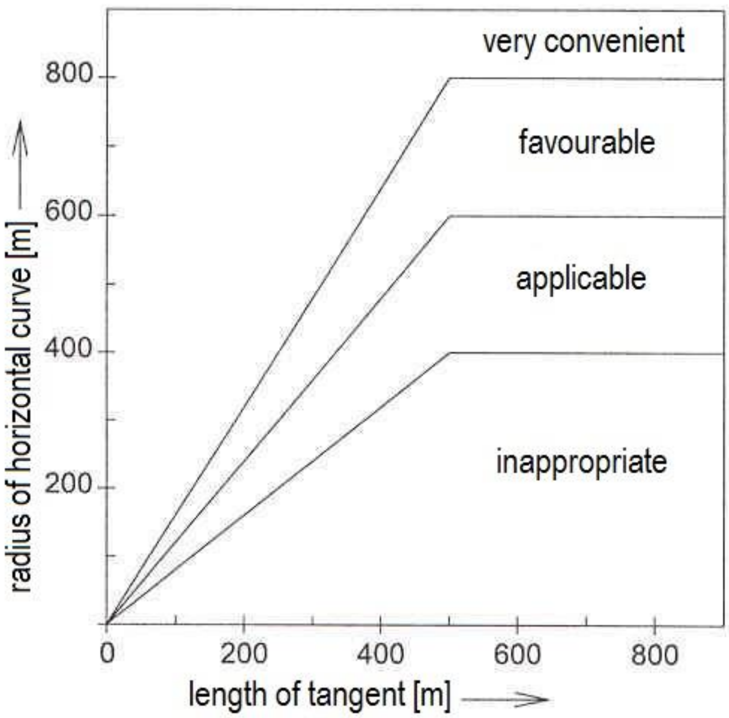

fig. 0080 (size of R depending on length of adjacent straight)

According to the knowledge of the category and the design speed "V" find and identify:

- maximum longitudinal gradient G_{max} (by *fig. 0020*)
- Maximum superelevation in curve S_{max} (according to *fig. 0030*) $\Rightarrow S_{max} \in \langle 2{,}5\%; 6\% \rangle$
- minimum radius of the horizontal curves R depending on the “V“ by *fig. 0030*
- minimum radius of the crest curves:
  - $R_{c,min}$ – by *fig. 0100* and *fig. 0110* (use the smallest allowed for stopping)

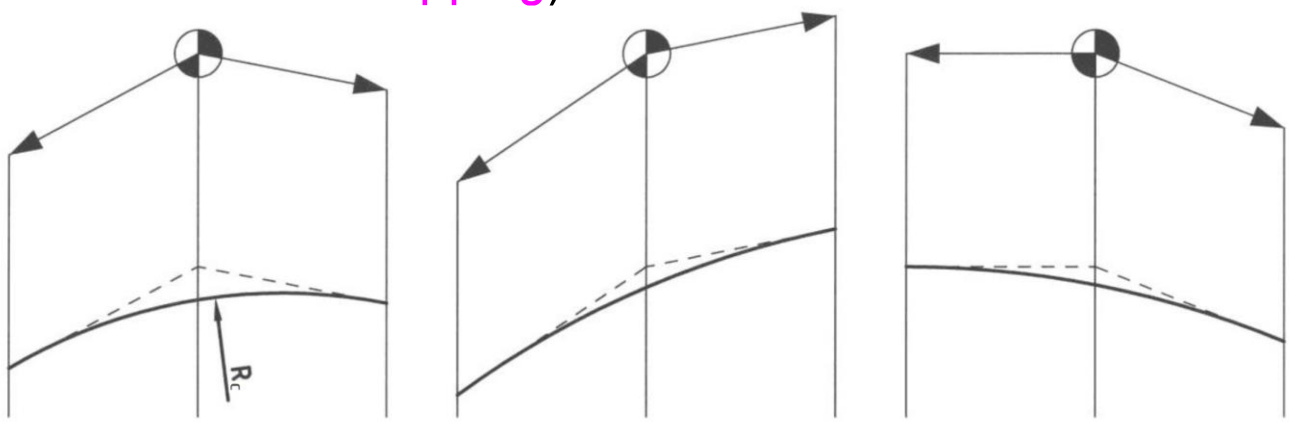

fig. 0100 (diagram R_c)

R_c [m]	at design speed [km/h]									
	130	120	110	100	90	80	70	60	50	40
smallest allowed for stopping	15 000	12 000	10 000	7 500	5 000	4 000	3 200	2 000	1 000	500
smallest allowed for overtaking	-	-	-	-	37 000	31 000	25 000	20 000	11 000	5 000

fig. 0110 (values $R_{c,min}$)

- minimum radius of the sag curves:
  - $R_{s,min}$ – by *fig. 0120* and *fig. 0130* (use the smallest allowed)

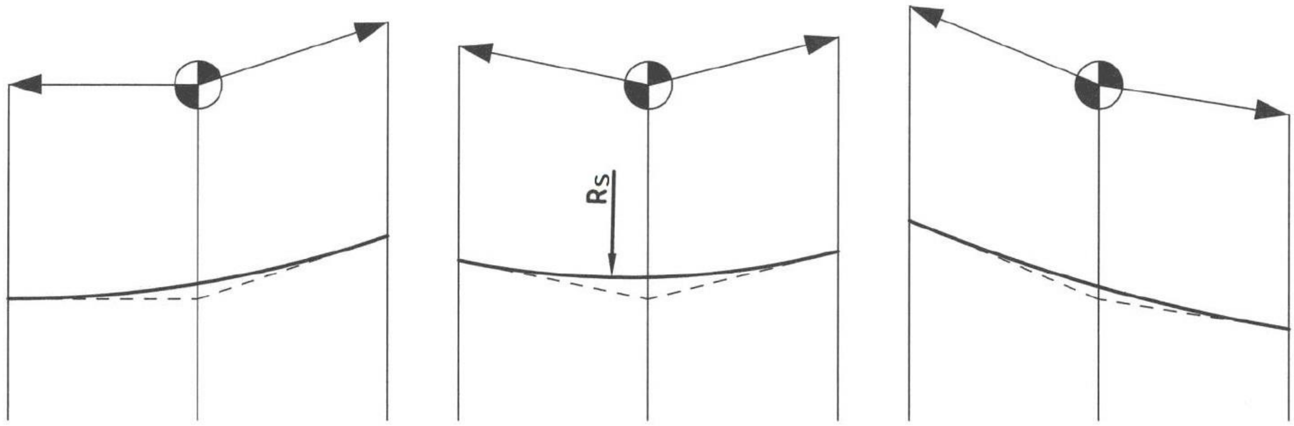

fig. 0120 (diagram R_s)

R_s [m]	at design speed [km/h]									
	130	120	110	100	90	80	70	60	50	40
smallest recomended	7 000	6 000	5 000	4 200	3 500	2 800	2 000	1 500	1 200	1 000
smallest allowed	6 000	5 000	4 000	3 400	2 700	2 100	1 500	1 000	700	400

fig. 0130 (values $R_{s,min}$)

- maximum drainage gradient M_{max} (by *fig. 0140*) – determined by terrain classification and road category

<table>
<tr><th rowspan="2">Design category of road or motorway</th><th colspan="3">Greatest allowed drainage gradient M [%] per terrain classification</th></tr>
<tr><th>level terrain</th><th>rolling terrain</th><th>mountainous terrain</th></tr>
<tr><td>D 33,5</td><td rowspan="3">6,5</td><td>7,0</td><td>7,0</td></tr>
<tr><td>D 27,5</td><td rowspan="4">7,5</td><td rowspan="3">7,5</td></tr>
<tr><td>S 24,5</td></tr>
<tr><td>S 20,75</td><td>7,0</td></tr>
<tr><td>S 11,5 a S 9,5</td><td rowspan="2">7,5</td><td>8,5</td></tr>
<tr><td>S 7,5 a S 6,5</td><td>8,5</td><td>10,0</td></tr>
<tr><td>S 4,0</td><td>11,0</td><td>12,0</td><td>13,0</td></tr>
</table>

fig. 0140 (values M_{max})