DRAFT VERTICAL ALIGNMENT - 2 VARIANTS:

1. **Generous variant (red colour)**
   - the lowest operating costs ⇒ not need to respect the terrain so much, you can apply large earthworks
   - a few (up to about 4) vertical curves
   - large radii of the vertical (R_S, R_C) curves (5~10 times the minimum values) ⇒ effort to achieve the possibility of overtaking
   - there may be some bridges (longitudinal profile ⇒ if embankments over 10 m high)
   - there may be some tunnels (only in mountainous terrain and only in case of sufficient height of overburden)
2. **Economical variant (green or blue colour)**
   - the lowest construction costs ⇒ the attempt to respect the terrain (avoid large earthworks)
   - more (more than 4) vertical curves (no more than 10)
   - almost minimum radii of the vertical (R_S, R_C) curves
   - respect the maximum height of cuttings and embankments (do not design tunnels, bridges only over watercourses)

LONGITUDINAL PROFILE

- scale 1 : 10 000 / 1 000 (banked) – recommended to draw in a scale of 1 : 1 000 / 100 and then re-scale through the scale command

- maximum height of embankment 10 m (over 10 m ⇒ bridges – also plotted in the plan according to *fig. 0040*)

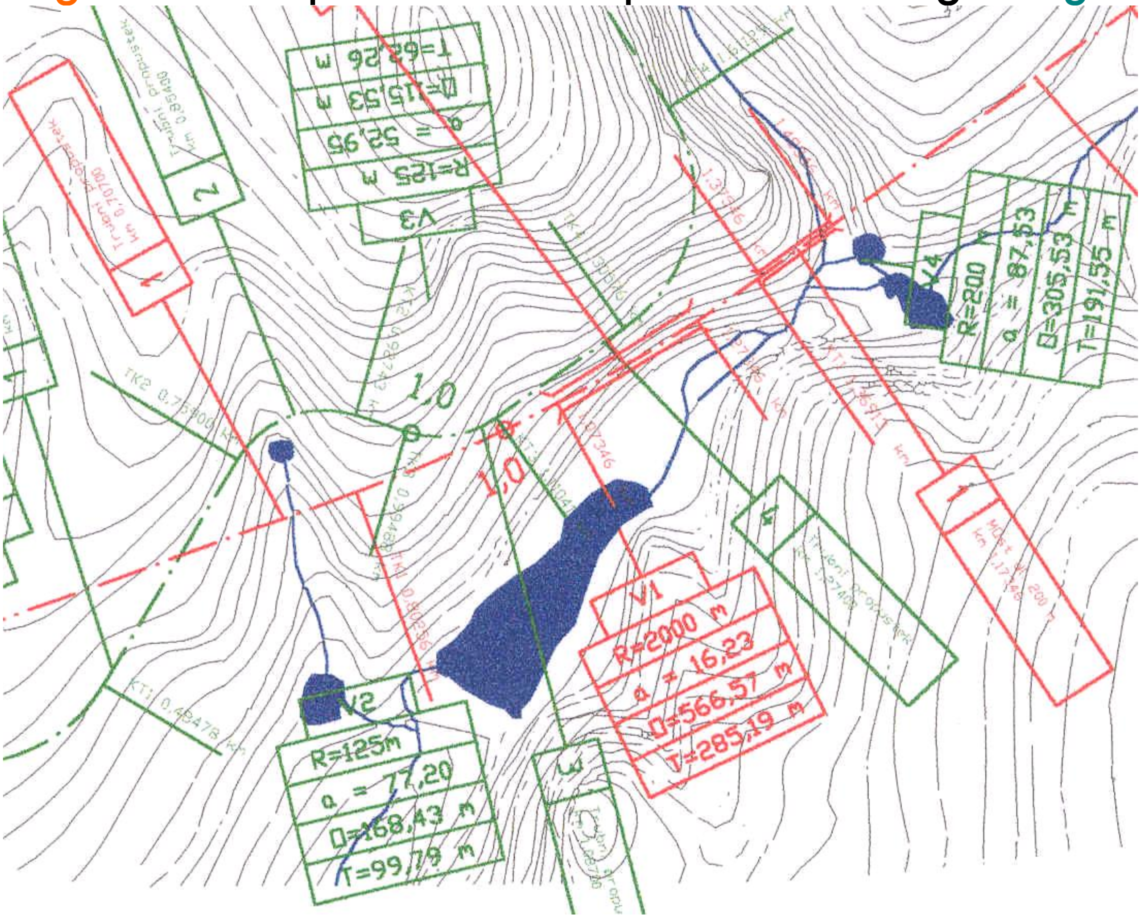

fig. 0040 (plan – chainage and table of objects)

- maximum height of cuttings ⇒ by terrain:
  - *level, gently rolling terrain.. 6 m*
  - *rolling terrain.. 7 m*
  - *mountainous terrain... 8 m*
- 10 cm between datum plane and minimum a vertical alignment or terrain line (100 m) – see *fig. 0150*
- 5 cm between datum plane and the bottom edge of the paper – see *fig. 0150*

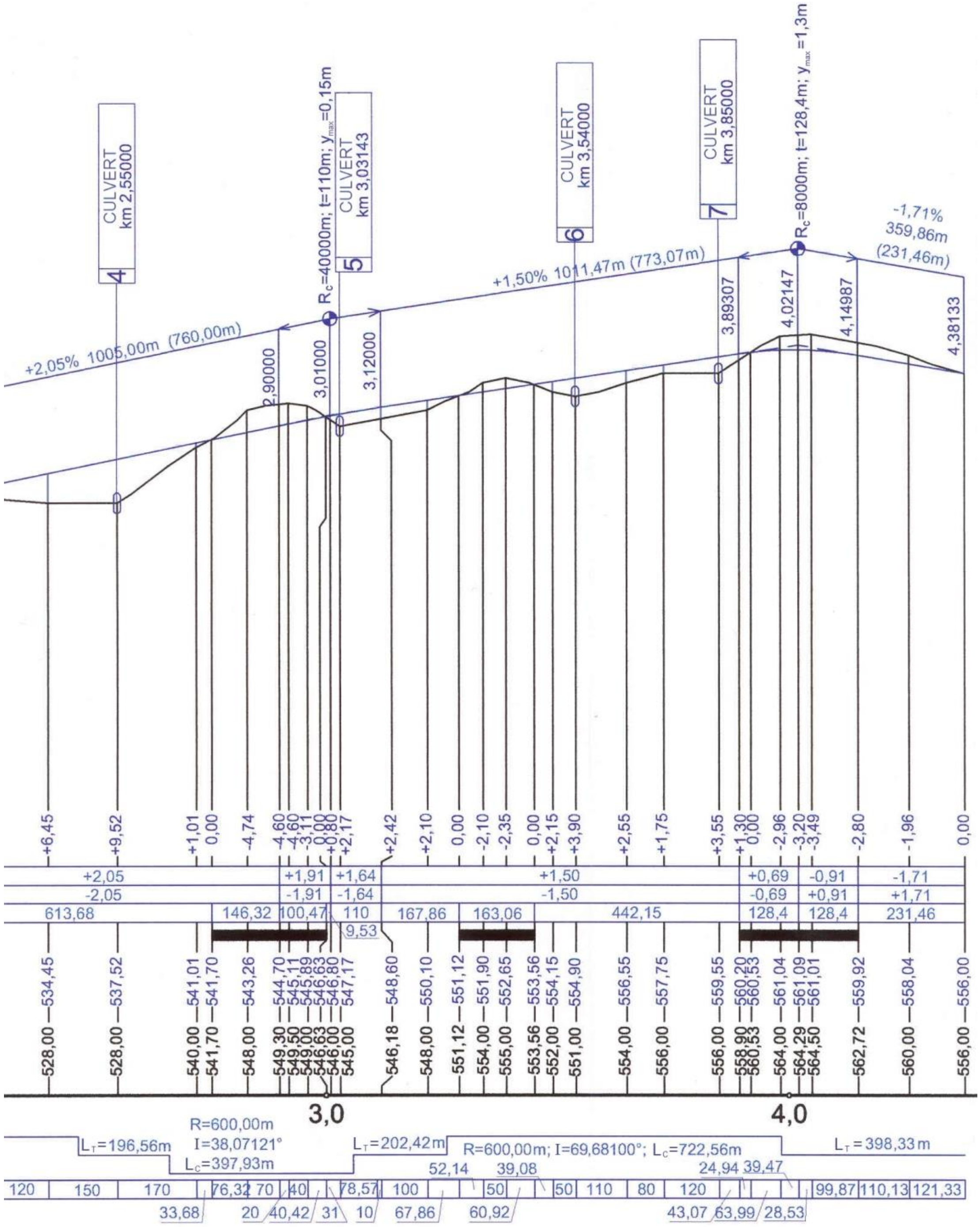

fig. 0150 (longitudinal profile – end part)

<u>Markings:</u>

(by *fig. 0160*)

- description of the vertical axis
- datum plane and chainage by 1.0 km
- terrain line (watch out ⇒ common mistakes! – the vertices are at each interstation of horizontal alignment and contour line, not in sections of constant length)

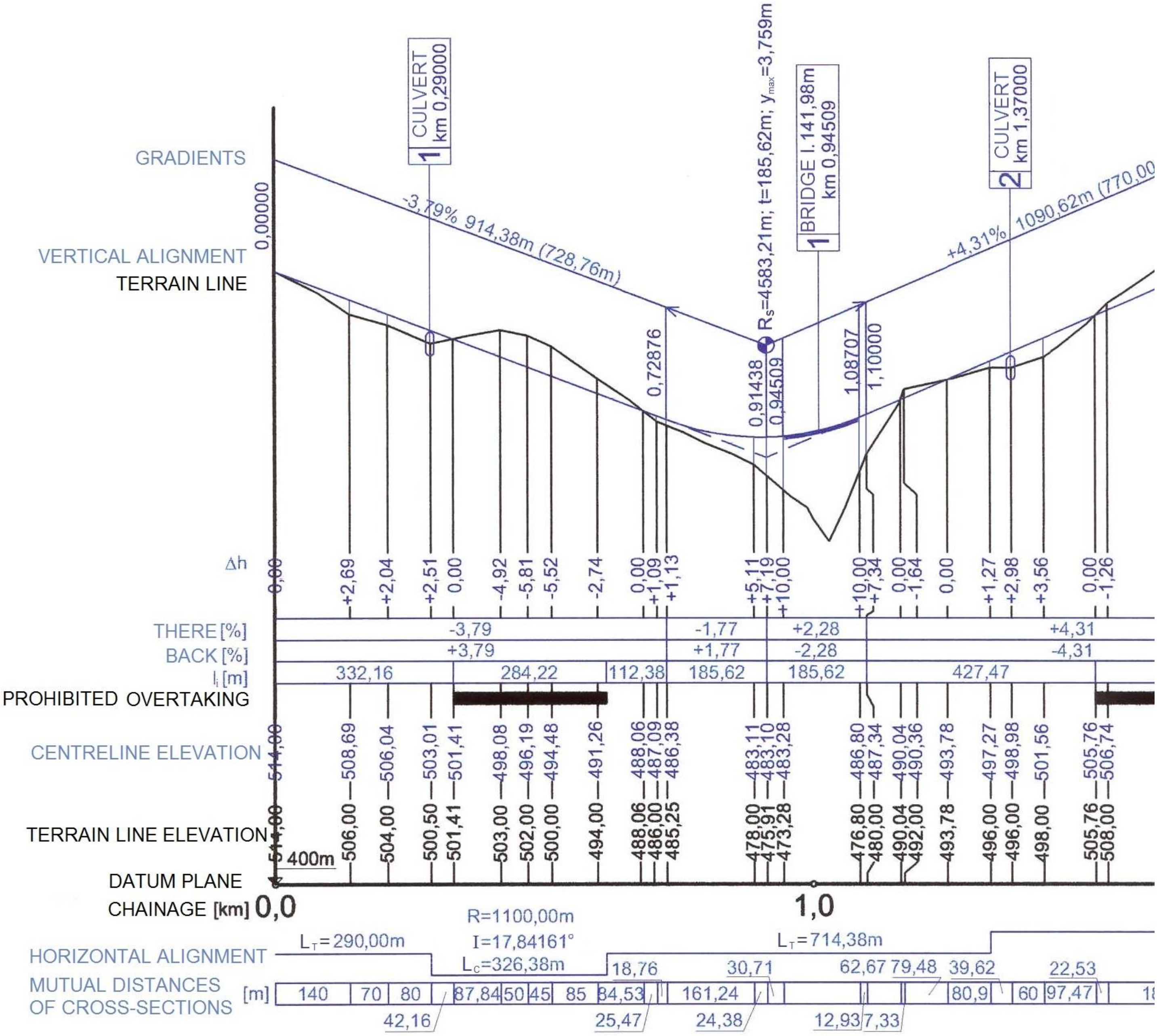

fig. 0160 (longitudinal profile – descriptions on the initial part)

- representation of horizontal alignment:
  - <u>fill in</u> – horizontal curve values: R, I, L_C plus L_T length of the straight stretch (tangent length) see *fig. 0160*
  - <u>types of curves</u> – diagram by *fig. 0170* and *fig. 0180*

fig. 0170 (longitudinal profile – right-hand horizontal curve)

fig. 0180 (longitudinal profile – left-hand horizontal curve)

- objects (table of bridge, tunnel or culvert – by *fig. 0160*)
- place vertices of the elevation polygon ⇒ measuring chainage and the elevation (see *fig. 0190* and *fig. 0200*)

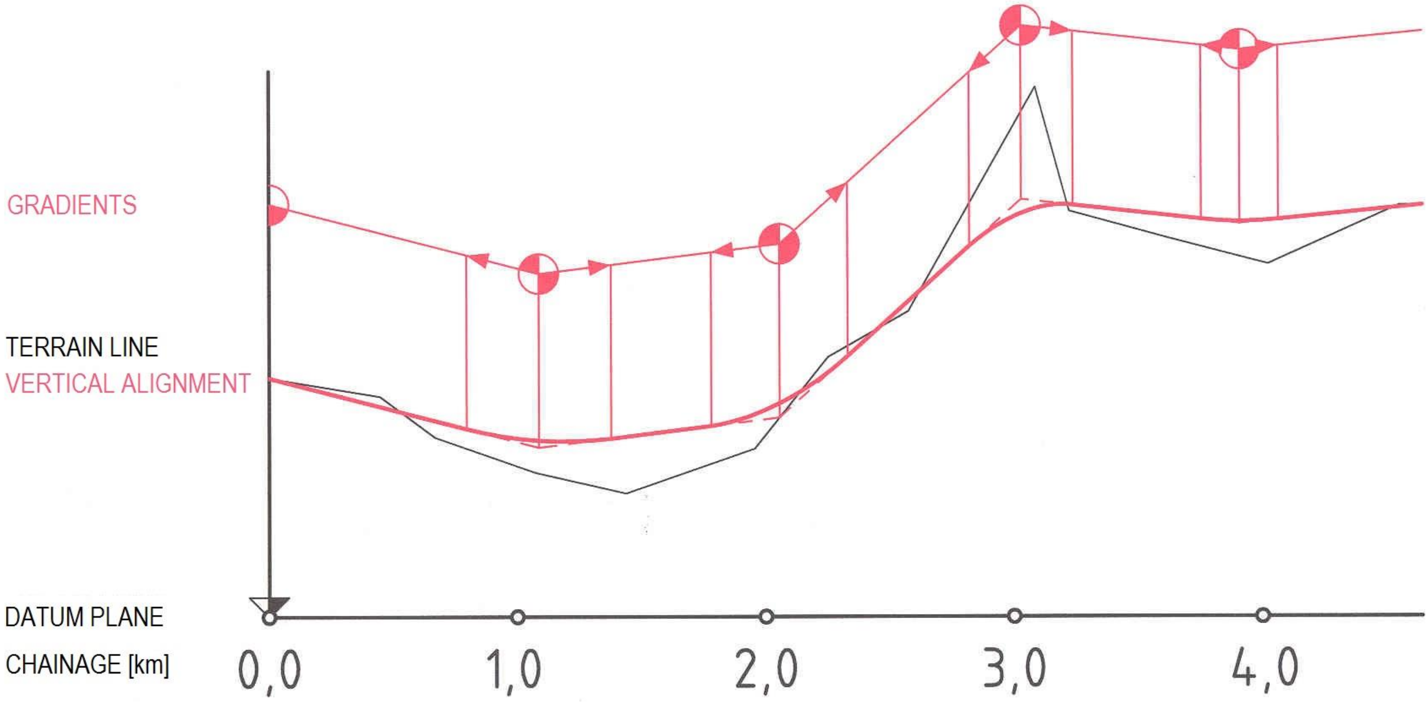

fig. 0190 (longitudinal profile – design of vertical alignment)

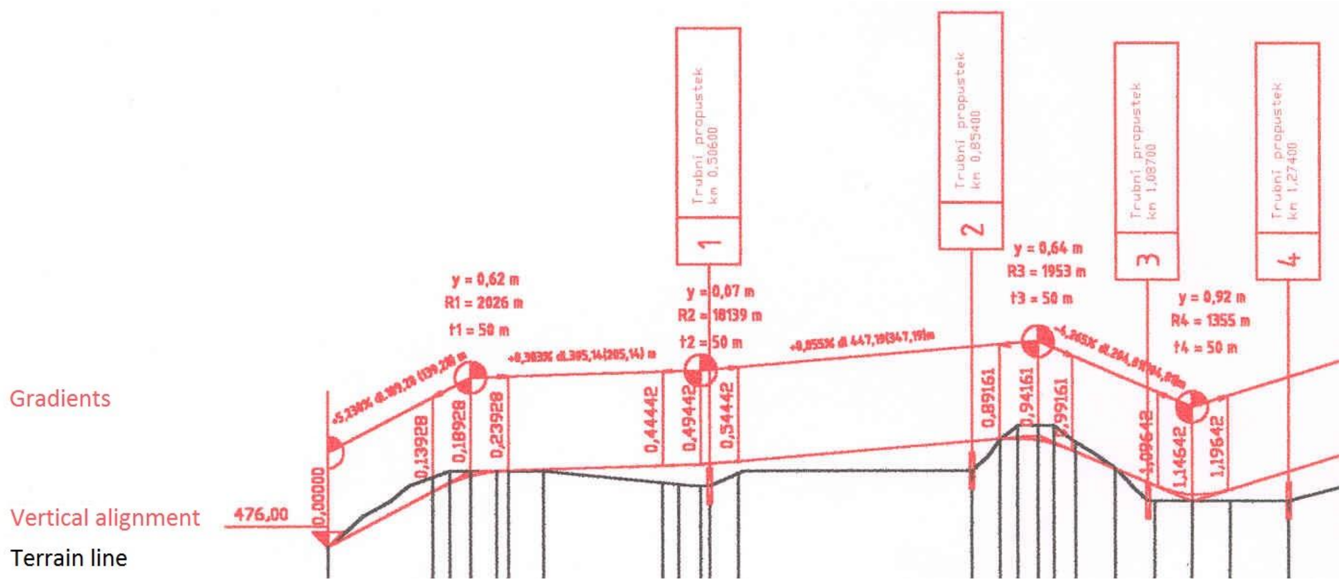

fig. 0200 (longitudinal profile – gradients marking)

❖ in the entire route must comply:

$$M_{max} \geq M = \sqrt{S^2 + G^2}$$

- *M [%] ..... drainage gradient*
- *S [%]...... superelevation (crossfall)*
- *G [%] ..... longitudinal gradient*

❖ gradients including chainage – vertical curvature (principle by *fig. 0210*):

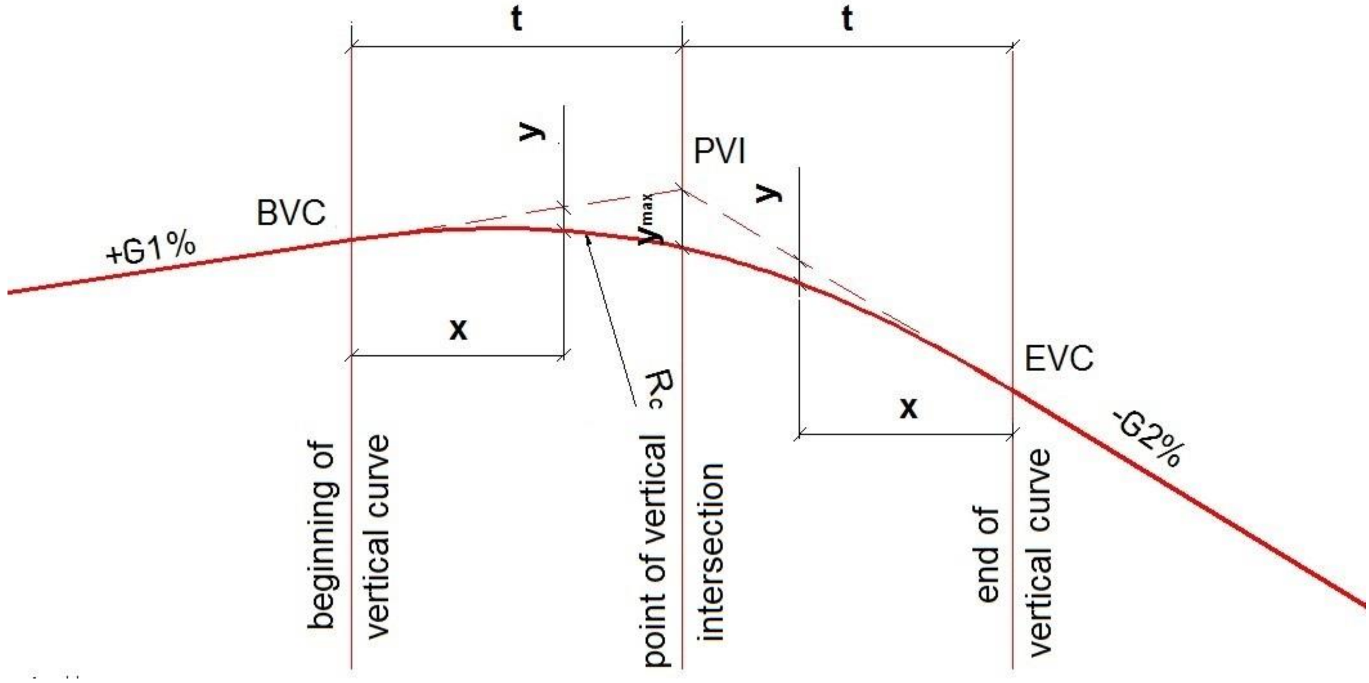

fig. 0210 (principle of vertical curvature)

opposite gradients:

$$t = \frac{R_{s/c} \bullet (\left| |G_1| + |G_2| \right|)}{200}$$

one-sided gradients:

$$t = \frac{R_{s/c} \bullet (\left| |G_1| - |G_2| \right|)}{200}$$

$$y_{max} = \frac{t^2}{2 \bullet R_{s/c}} \qquad y = \frac{x^2}{2 \bullet R_{s/c}}$$

❖ calculate using the tabulated longitudinal profile (see course 12PPOK) elevation of the vertical alignment in „m“ to 2 decimal places (ATTENTION TO ROUNDING!!!)

– see *fig. 0210*) in each cross sections ⇒ place cross section in these spots (see example *fig. 0160*):

- *"zero profile" (equal elevation of vert. align. and terrain)*
- *local extremes of terrain elevation*
- *change of elevation difference "vert. align. - terrain"*
- *beginning and end of the bridge or tunnel (cross sections are unnecessary on the bridge or in a tunnel)*

❖ fill the elevations of vertical alignment and the elevations of terrain in longitudinal profile (by *fig. 0160*)

❖ fill further info to the longitudinal profile (by *fig. 0160*):

- *Δh = elevation difference "vertical alignment – terrain"*
- *mutual distance of cross sections in "m"*

❖ plot stretches with prohibited overtaking „l_{PO}" (model according to an example *fig. 0150* and *fig. 0160*) – in locations that meet the following conditions:

- *horizontal curves located in the cutting*
- *crest curves where $R_c \leq R_{c,min}$ (allowed for overtaking)*

❖ mark lengths „l_i" and values of constant gradient for directions "THERE" and "BACK" (according to *fig. 0160*):

- a route is divided into sections of the same gradient, the vertical curves are replaced by 2 secants (see *fig. 0220*) from the point of beginning of the vertical curve to point of vertical interception (BVC – PVI ⇒ gradient G_1') and from the point of vertical interception to point of end of the vertical curve (PVI – EVC ⇒ gradient G_2')

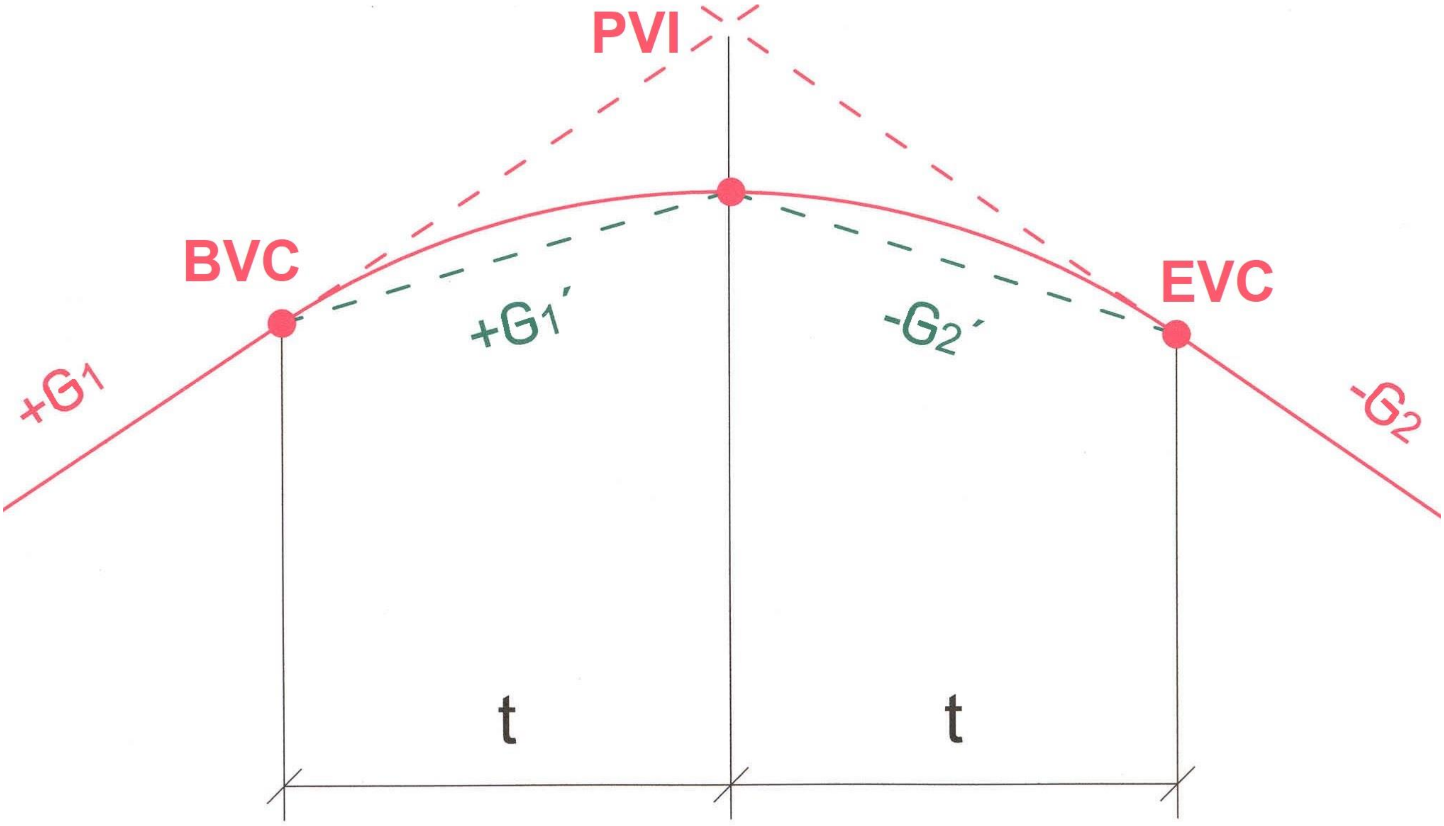

fig. 0220 (replacement of the vertical curve with 2 secants with gradients G_1´ and G_2´)

- gradients G_1´ and G_2´ accurately calculate from the known values of the vertical alignment in points BVC, PVI and EVC (by *fig. 0220*)
- sections lengths „l_i“ are between the points:
  - *BVC, PVI and EVC (at each vertical curve)*
  - *between the beginning and at the end of each section with prohibited overtaking*