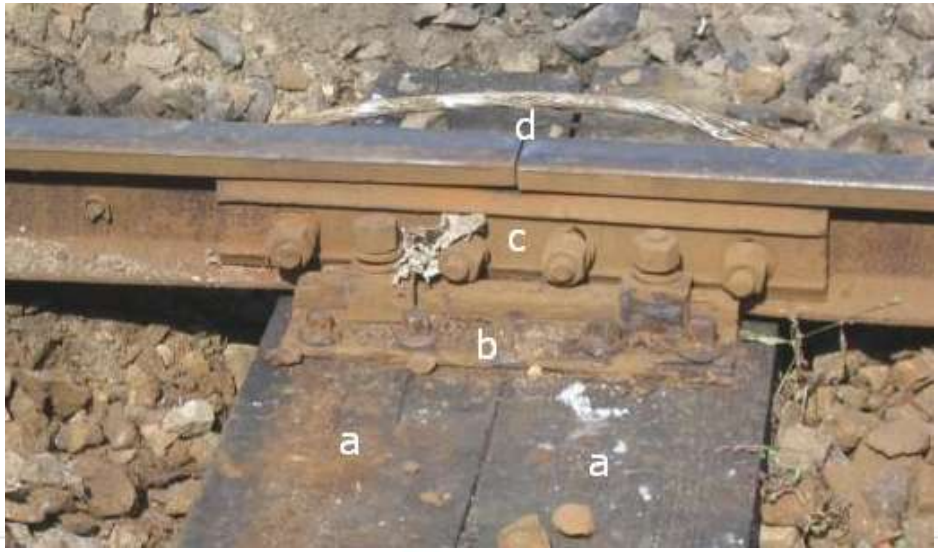
RAILWAYS

1. Continuous welded rails
2. Grade crossing



Continuous welded track

Continuous track is a structure made of welded sections of rails in one long rail of width from 180 m to (even!) a few kilometres (theoretically unlimitedly long). In such a rail, without the freedom of longitudinal displacement, some stress appear. It is caused by the difference of the assembling temperature and the current temperature.



VS



Continuous welded track

In the classic track the dilatation phenomenon occurs:

$$\Delta l = \alpha \, l \left(T_N - T \right)$$

where:

- α - thermal dilatation coefficient of the steel (1.12 - 1.15 · 10^{-5} [1/ºC]),
- l - length of the rail [m],
- T_N - the assembling temperature – usually from +15 to +30 [ºC],
- T - the current temperature – from -15 to +60 [ºC].

The force acting on a rail is:

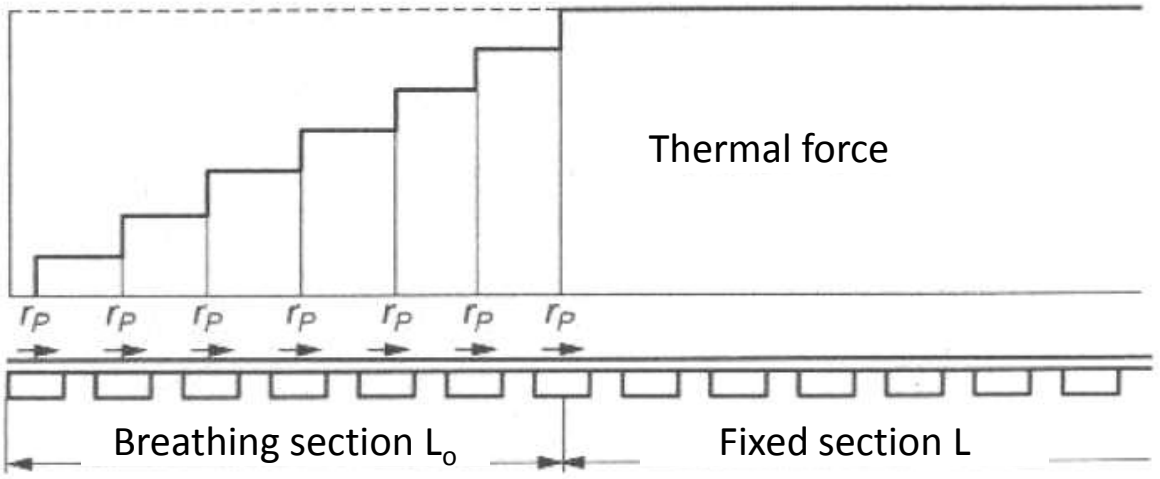
$$F = \alpha \, EA \left(T_N - T \right)$$

Independent of the length!

where:

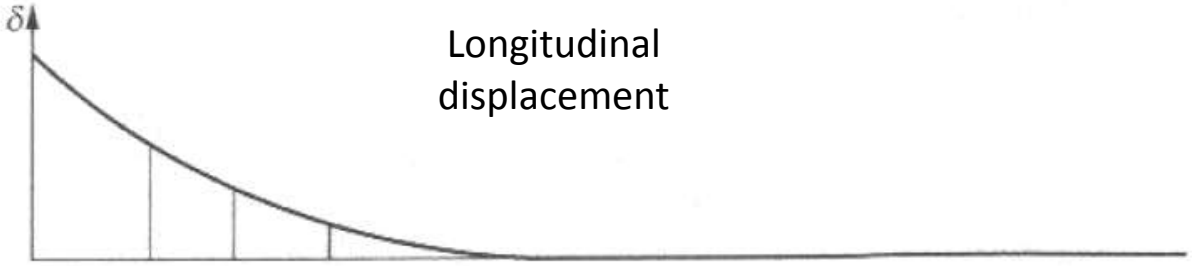
- E – Young modulus of steel (210 GPa),
- A – the rail cross section area [m^2].

Thermal forces and longitudinal displacement



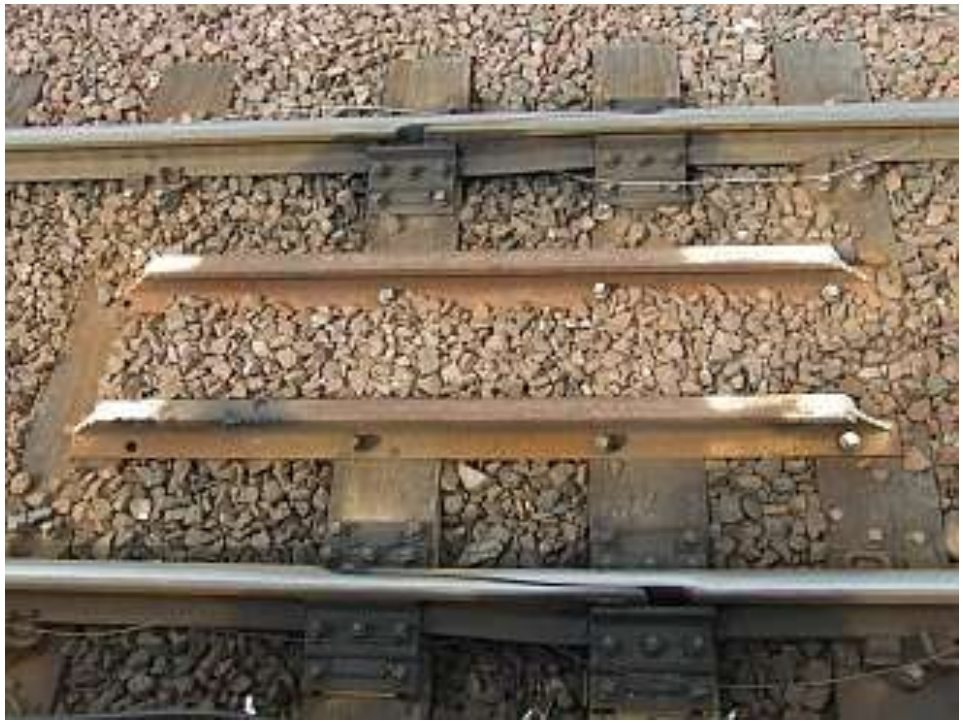
$$L_o = \frac{2\alpha\, EA\left(T_N - T\right)}{r_p}$$

In practice
L_o= 30-60 m



Resistance against the longitudinal displacement r_p :

- in the track on wooden sleepers 10-12 kN/m (when frozen 30 kN/m),
- in the track on concrete sleepers 15 kN/m (when frozen 40 kN/m).





The end of the breathing section
with the dilatation device

Advantages and disadvantages

+ Smoother ride
+ Less friction
+ No risk of 'squ
+ Less noise and



- Difficult prope
- Heavy track
- More prone t winter

Thermal failures



Fracture of the rail due to decrease of temperature and the vertical operational load.



Buckling of the track in horizontal plane due to increase of temperature and weak horizontal support of the ballast.

Thermal failures

Buckling of the track in horizontal plane due to increase of temperature and lack of the ballast





Buckling of the rail in vertical plane due to increase of temperature and the weak fastening element.

Thermal failure

The danger of thermal failure – what plays a role?

1. Thermal force
2. Stiffness of the track frame
3. Mechanical properties of the ballast (horizontal resistance)
4. Curvature of the track due to design
5. Imperfections of the track

According to Euler's theory the critical force is: $$P_E = \frac{\Pi^2 EI}{l^2}$$
where *EI* – stiffness of the bar, *l* – the free length of the bar.

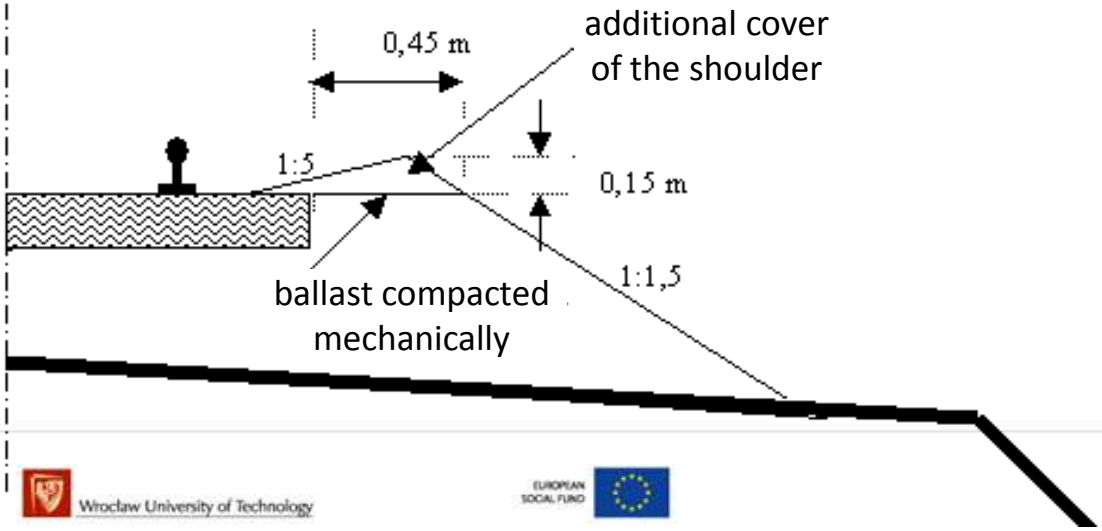
For a beam on the springy foundation: $$P_c = 2\sqrt{EIC}$$
where *C* – elasticity coefficient of the foundation.
The length of the buckling wave λ can be calculated: $$\lambda = \Pi \sqrt[4]{\frac{EI}{C}}$$

Buckling caused by embankment failure – not related to rail welding



CWT – design requirements

- minimal radius of curve: --> on line: 600 m
  --> on station: 300 m,
- CWT mustn't start nor finish on a transition curve,
- longitudinal inclination has to be less than 12‰,
- CWT shouldn't be applied in region of landslides, active mining exploitation, soft ground etc.,
- the shoulder should have at least 45 cm,
- fastening elements: spring fastening or K, assuring the fixing force 8-12 kN.
- rail welding technologies:
  --> flash butt
  --> thermite
  --> electric arc
- assembling should be done at a neutral temperature (15-30°C).



Thermite welding

Thermite – a mixture of powdered aluminium and iron oxide.

In the thermite reaction aluminium rapidly reduces oxides of metal and produces energy with one of the highest temperature in industrial processes (around 3000 °C and with special additives even 3800 °C). As the products of the reaction aluminium oxide and liquid iron is obtained.

If thermite is made of iron oxide for the maximum effectiveness it should contain 25,3% of aluminium and 74,7% of iron oxide. The reaction looks like that:

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe; \quad \Delta H = -851{,}5 \text{ kJ/mol}$$

but if thermite is made with use of $FeO \cdot Fe_2O_3$, the optimal proportions are 23,7% of aluminium and 76,3% of the oxide. The reaction runs according to the formula:

$$3Fe_3O_4 + 8Al \rightarrow 4Al_2O_3 + 9Fe; \quad \Delta H = -3347{,}6 \text{ kJ/mol}$$



Preparation of the rails



Fixed form



Heating the rails



Burning of thermite



Melting of iron



Grinding of the joint

Flash butt welding

Flash welding is a kind of resistance welding that involves pressing two ends together, while simultaneously running a current between them. This has the effect of forming a joint between the two metals that is free of oxides as the surfaces of the two joining parts are forced out the sides. Welding equipment can be fitted on both rail vehicle or road-rail vehicle. Rail webs on both sides demand some preparation for better electric conductivity (rust and dirt removal). The whole process is quicker (few minutes) and more precise than thermite welding.





Electric arc welding

Electric arc welding is a method in which an electric arc is used for heating the 2 pieces of rail. Welding by this method is a manual work performed by a qualified welder. For welding the zone has to be prepared by removing the dirt and grease and it has to be pre-heated to around 300-380°C directly before welding. Welding of the rail is carried out in layers: 3 layers on the foot, then the web and finally 3 layers on the head (with a small over-dimension on the top, which will be grinded). After the welding is done a zone of 1 m on both sides has to be heated for relaxation of welding stresses.

This method can be applied in tracks:

- side tracks on stations and on sidings,
- turnouts,
- reparation of fractured rails,
- tramway tracks.





Grade crossing / level crossing









Grade crossing infrastructure



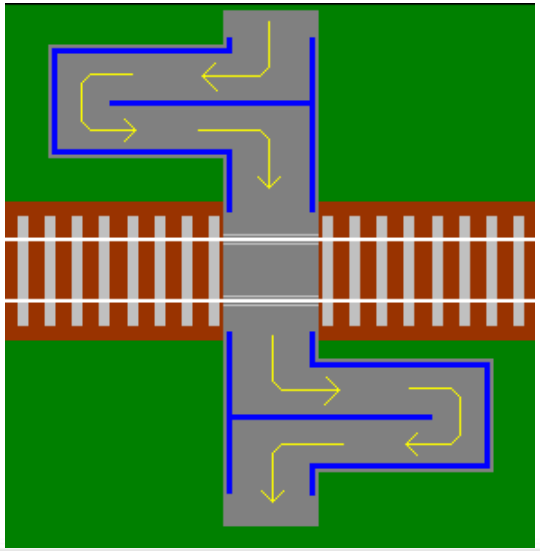


Movable fencing

Warning devices:

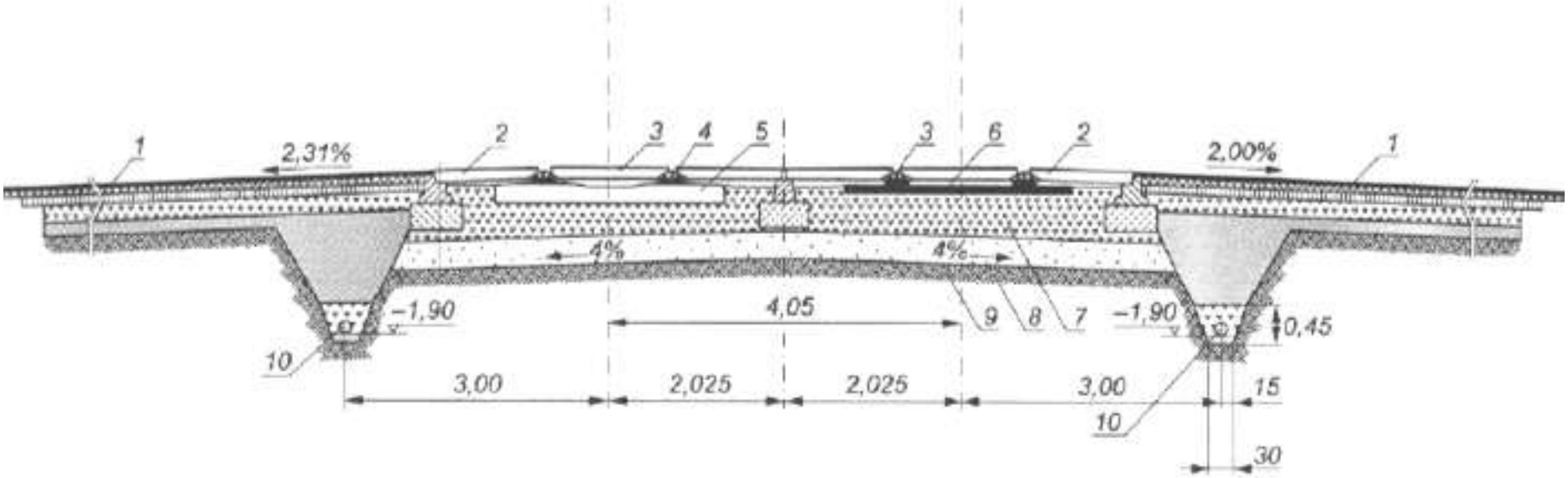
- the bell,
- the flashing light,
- the cross sign,
- the STOP sign





The fence in a labyrinth shape

Cross section of the grade crossing



Cross section of grade crossing of double track line: 1 – road pavement, 2 – field concrete slab, 3 – gauge concrete slab, 4 – rail, 5 – concrete sleeper, 6 – wooden sleeper, 7 – ballast, 8 – subbalast, 9 – trackbed, 10 - drainage

Grade crossing pavement systems

1. Rubber pavement:
   - → system KOLDROG (PL)
   - → system Iwiny (PL)
   - → system STRAIL
   - → system HiRail
2. Concrete pavement:

   a) small elements:
      - → WPS Mirosław Ujski (PL)
      - → system BODAN,

   b) large elements:
      - → CBP (Concrete Sleeper Plants in Bogucice and in Suwałki) (PL)
      - → Edilon LC-L

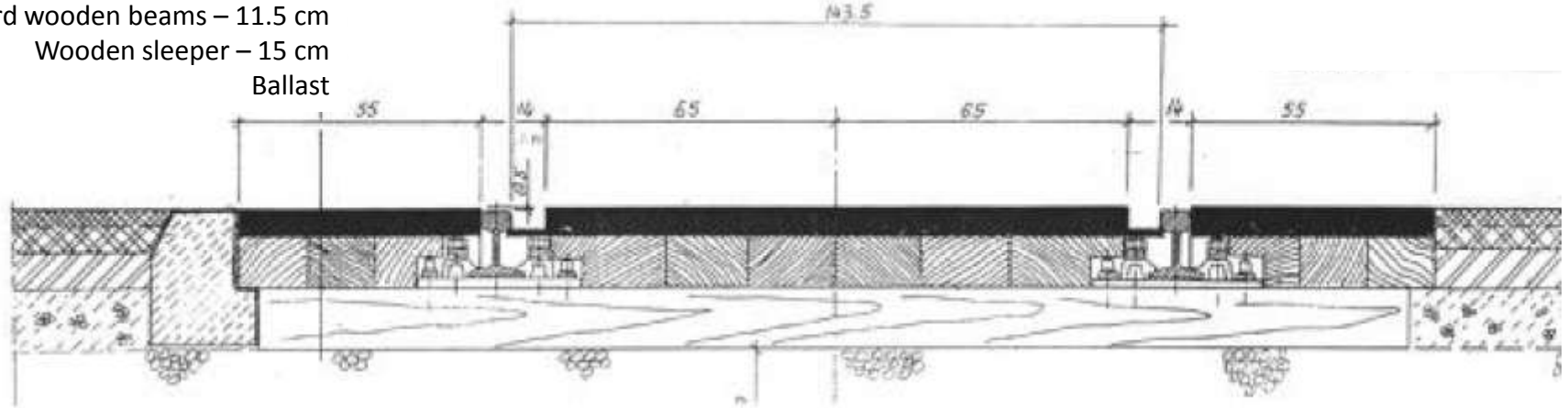
3. Wooden pavement

KOLDROG

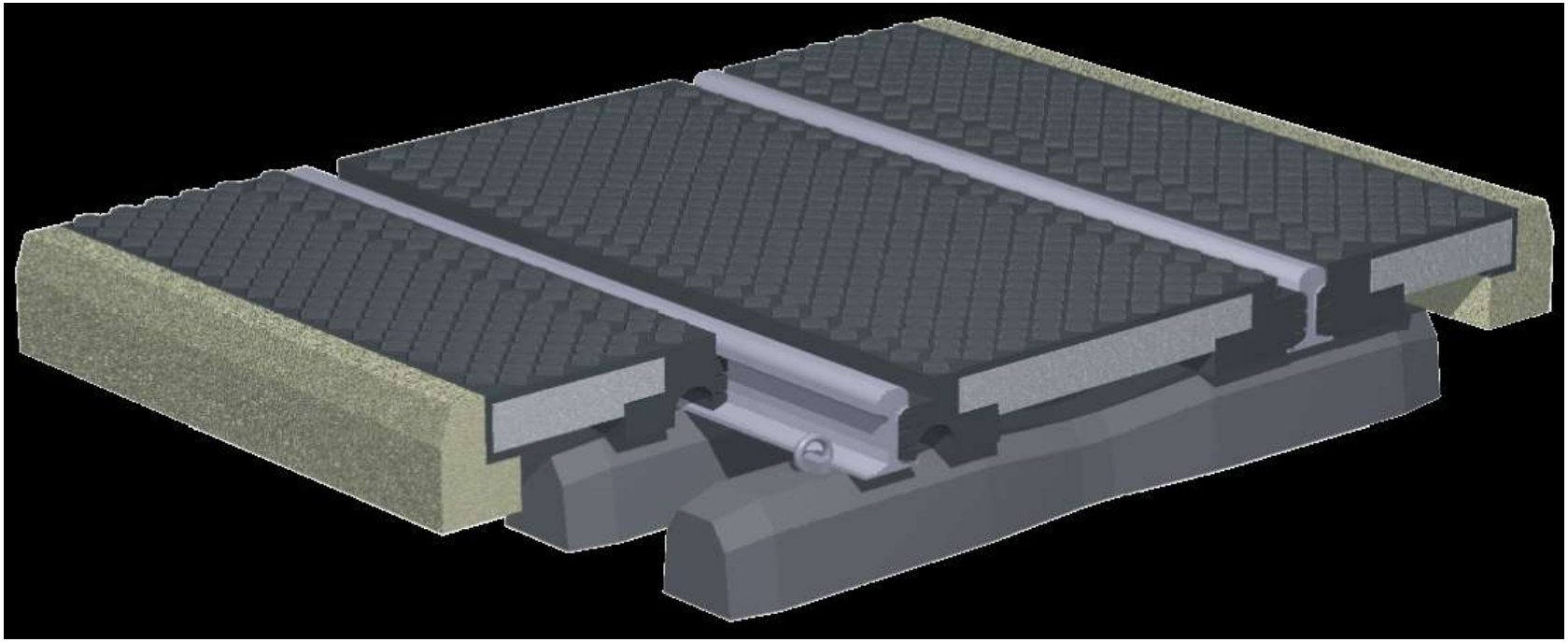


Rubber panels on wooden cross-beams structure

Rubber panels – 6 cm
Hard wooden beams – 11.5 cm
Wooden sleeper – 15 cm
Ballast



IWINY

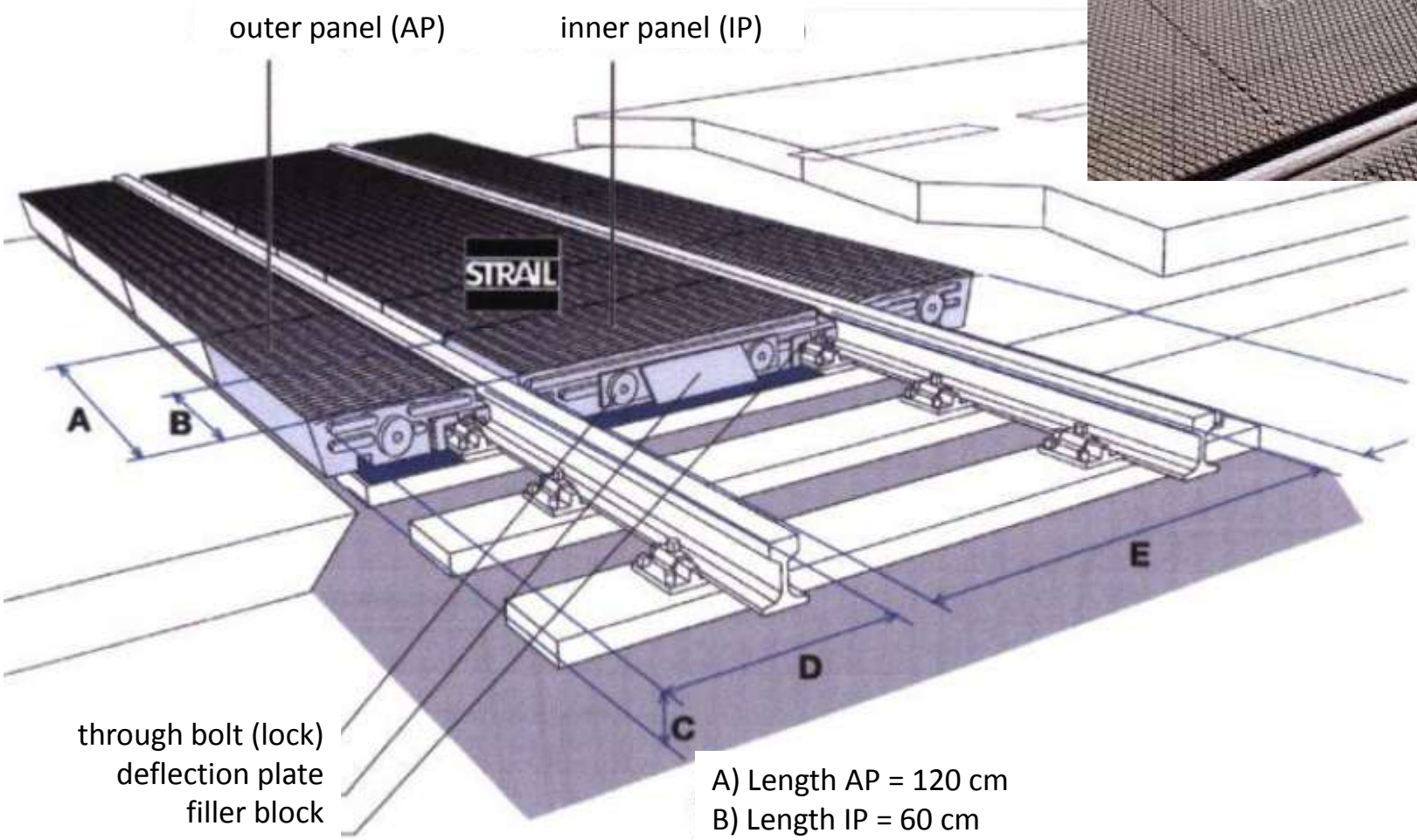


Concrete panels covered by rubber can be applied in places where there is a requirement for damping of noise and vibrations.
An important property of the panels covered by rubber is the high value of friction coefficient, thus it is recommended for its use in places subject to oil dirt and, in combination with a special tread, also in places subject to ice.
Panels 90x90x10 cm can be reinforced by single or double steel wire mesh (the upper wires ϕ8 mm and the bottom wires ϕ10 mm).

STRAIL

http://www.strail.de/

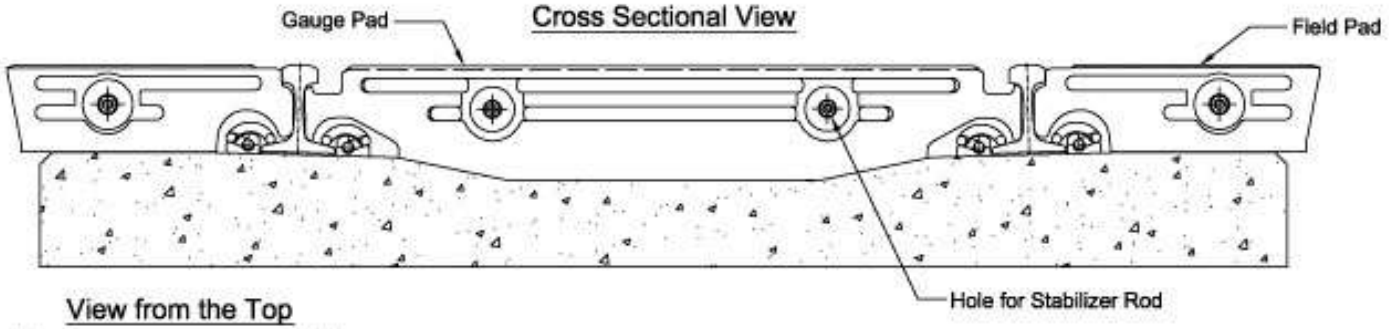


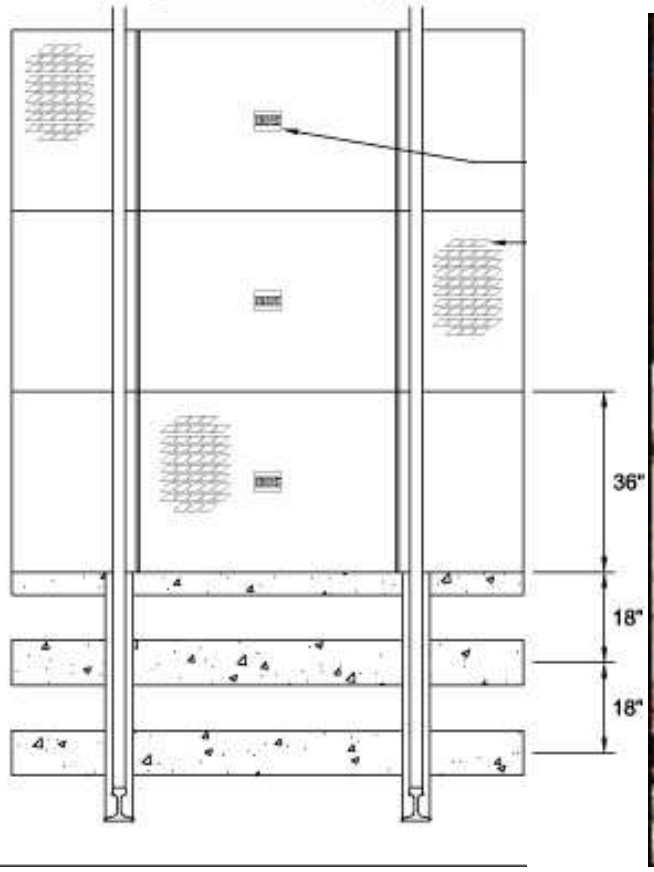


A) Length AP = 120 cm
B) Length IP = 60 cm
C) Height – up the track pavement
D) Width AP = 59.1 cm
E) Width IP – depending on the track gauge

http://www.hirail.com/

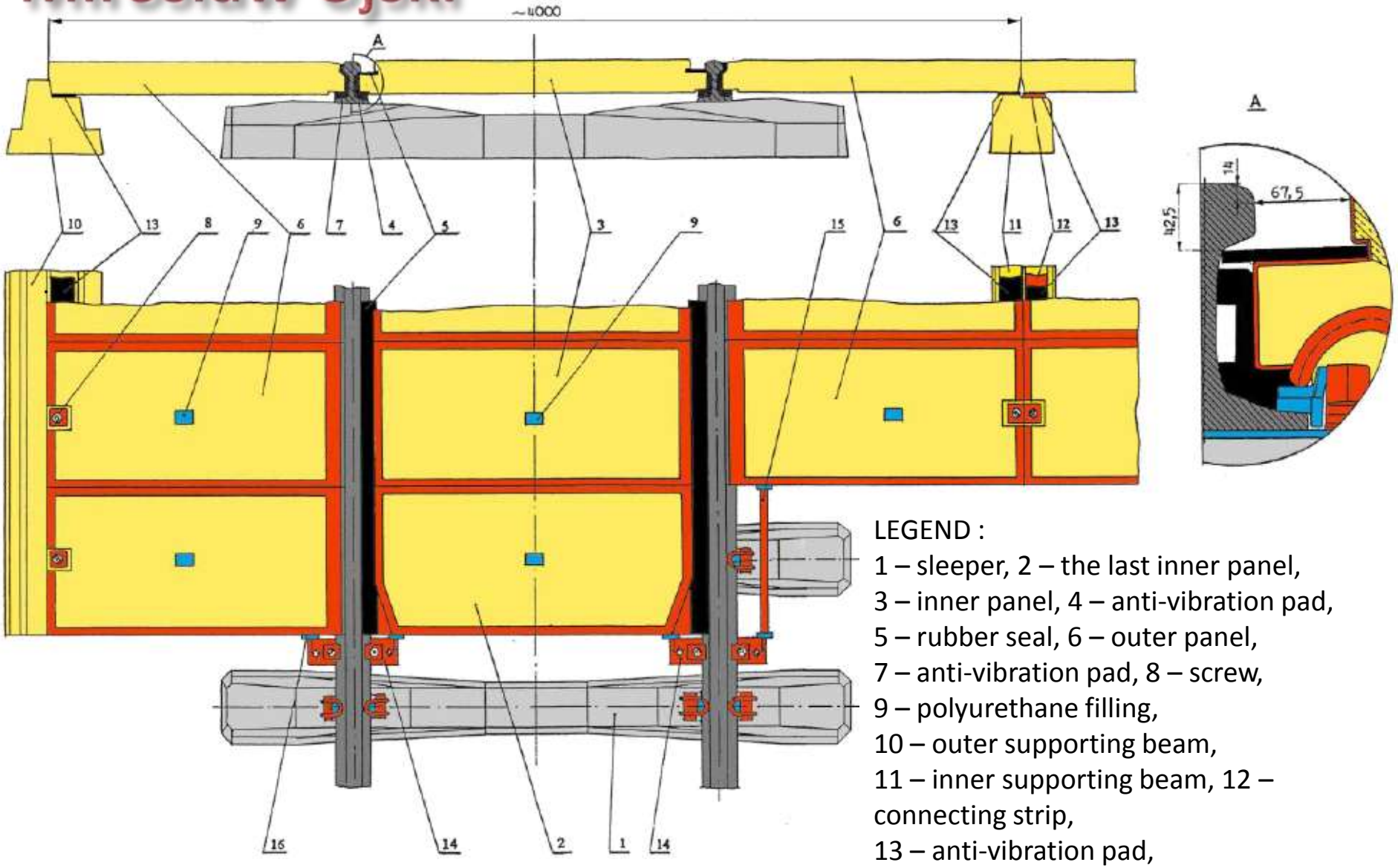
HiRail







Mirosław Ujski



LEGEND :
1 – sleeper, 2 – the last inner panel,
3 – inner panel, 4 – anti-vibration pad,
5 – rubber seal, 6 – outer panel,
7 – anti-vibration pad, 8 – screw,
9 – polyurethane filling,
10 – outer supporting beam,
11 – inner supporting beam, 12 – connecting strip,
13 – anti-vibration pad,
14 – blocking clamp, 15 – connector,
16 – PE cap

Mirosław Ujski

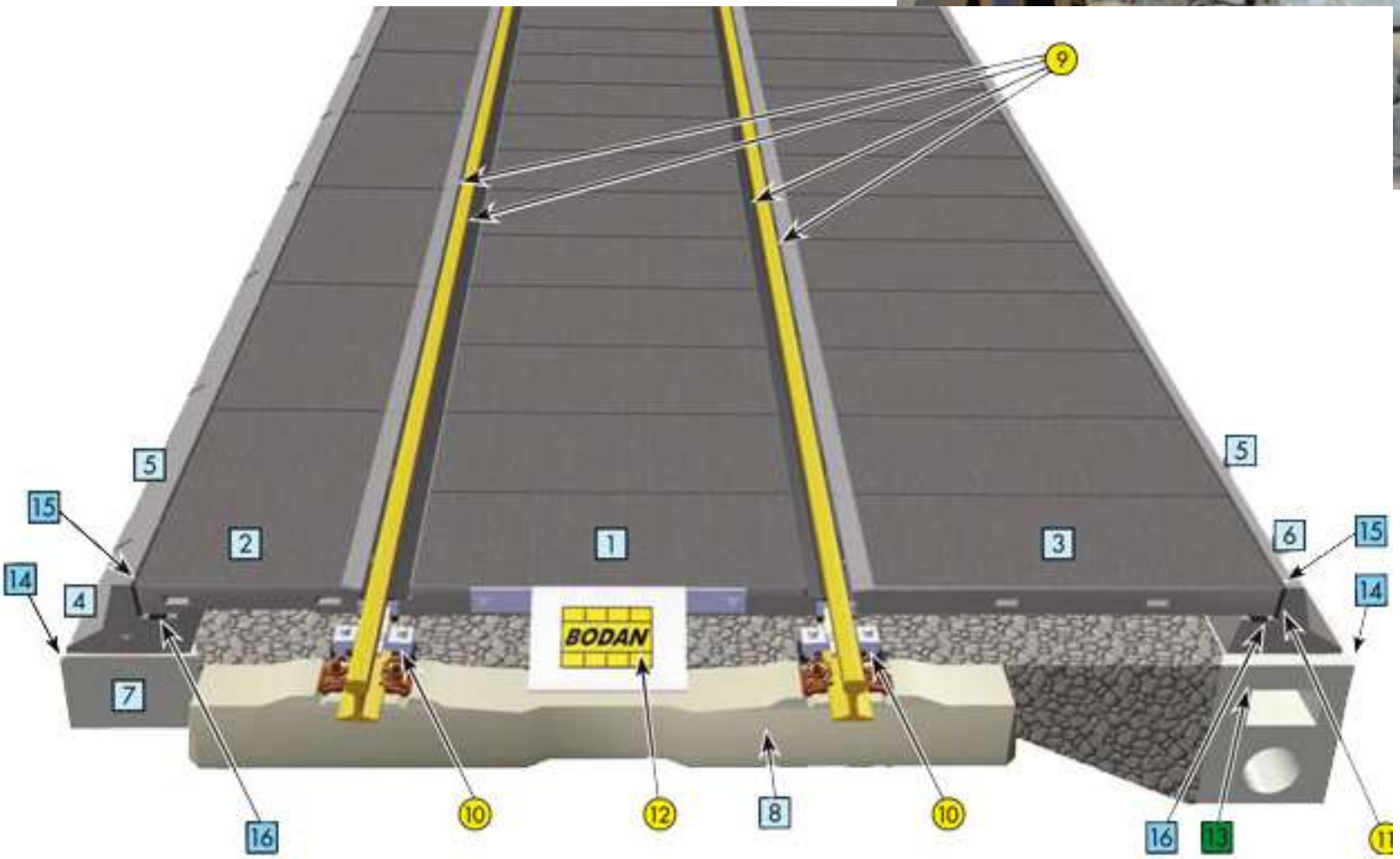
http://www.wps-sa.com.pl



BODAN

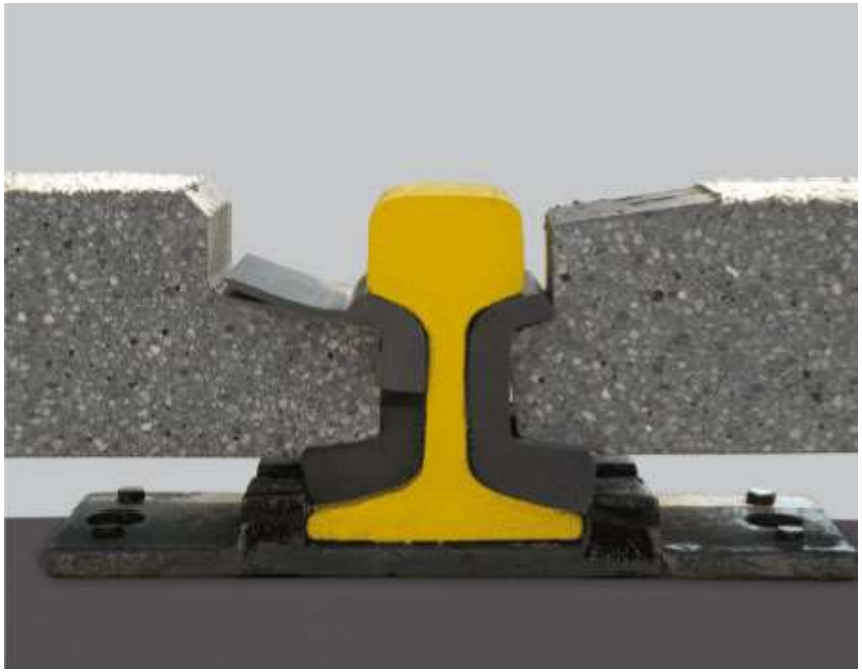
http://www.gmundner-ft.at/





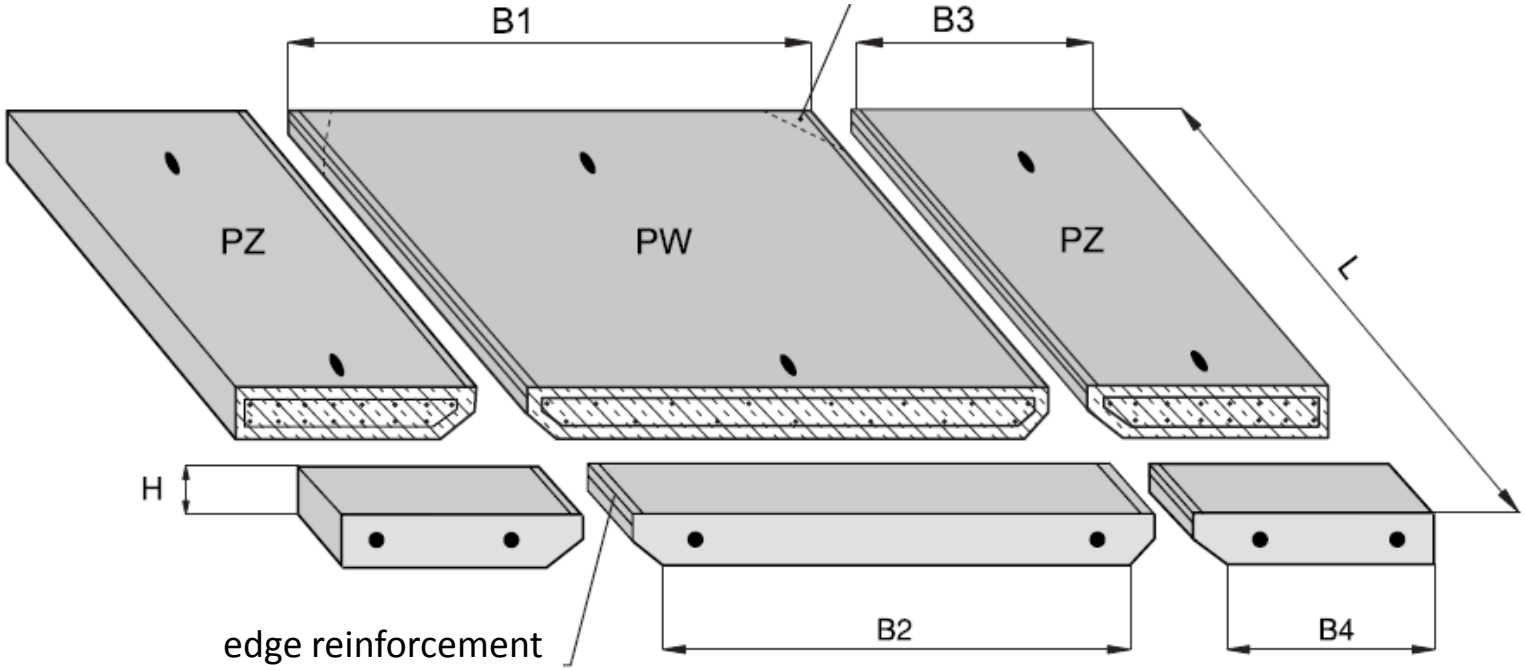
BODAN







CPB





WPS Bogucice/Suwałki

http://www.strunbet.pl/

EDILON



Ballastless integrated rail-road pavement

- crushed stone compacted in layers up to module $E_2 \geq 120$ MPa,
- precast reinforced concrete slabs Edilon LC-L
- as the fastening the ERS system is applied which ensures linear support and fastening of the rails to the slab.

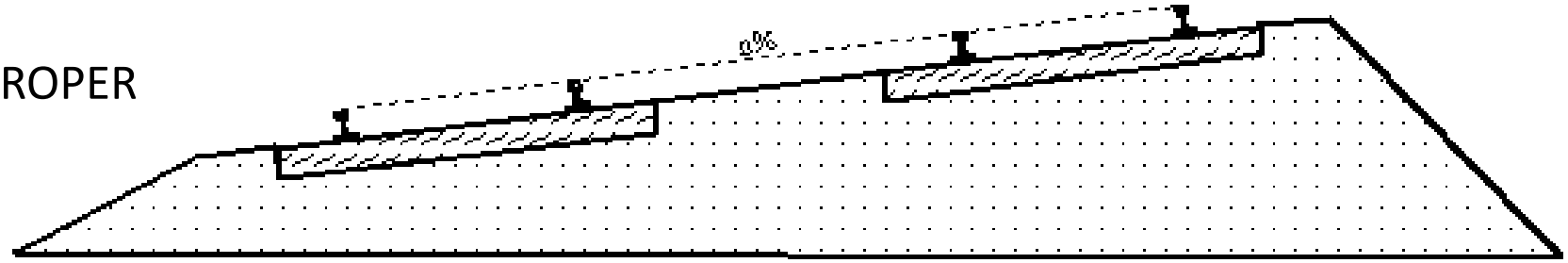
Wooden pavement



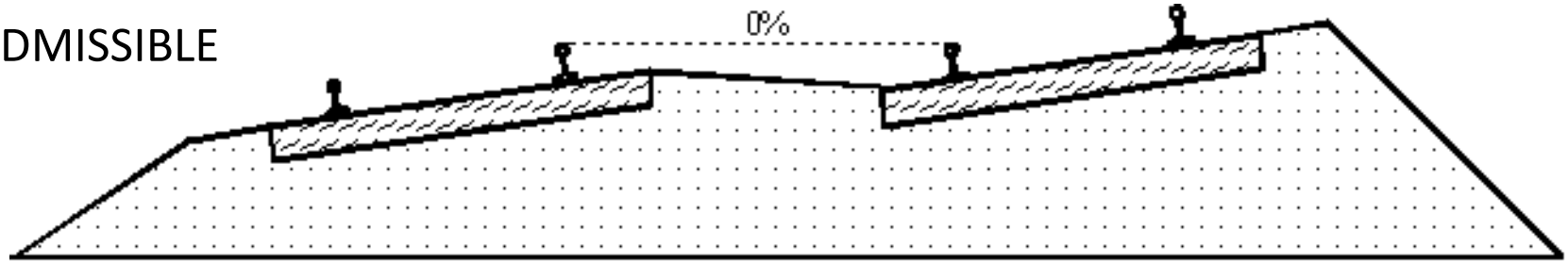
Geometry of the curved track

1. The arc section of the track should have the radius long enough to equip the track with a cant enabling continuation of the longitudinal inclination of the road not exceeding 2,5%.
2. The grade crossing shouldn't be designed on the length of transition curve.

PROPER



ADMISSIBLE



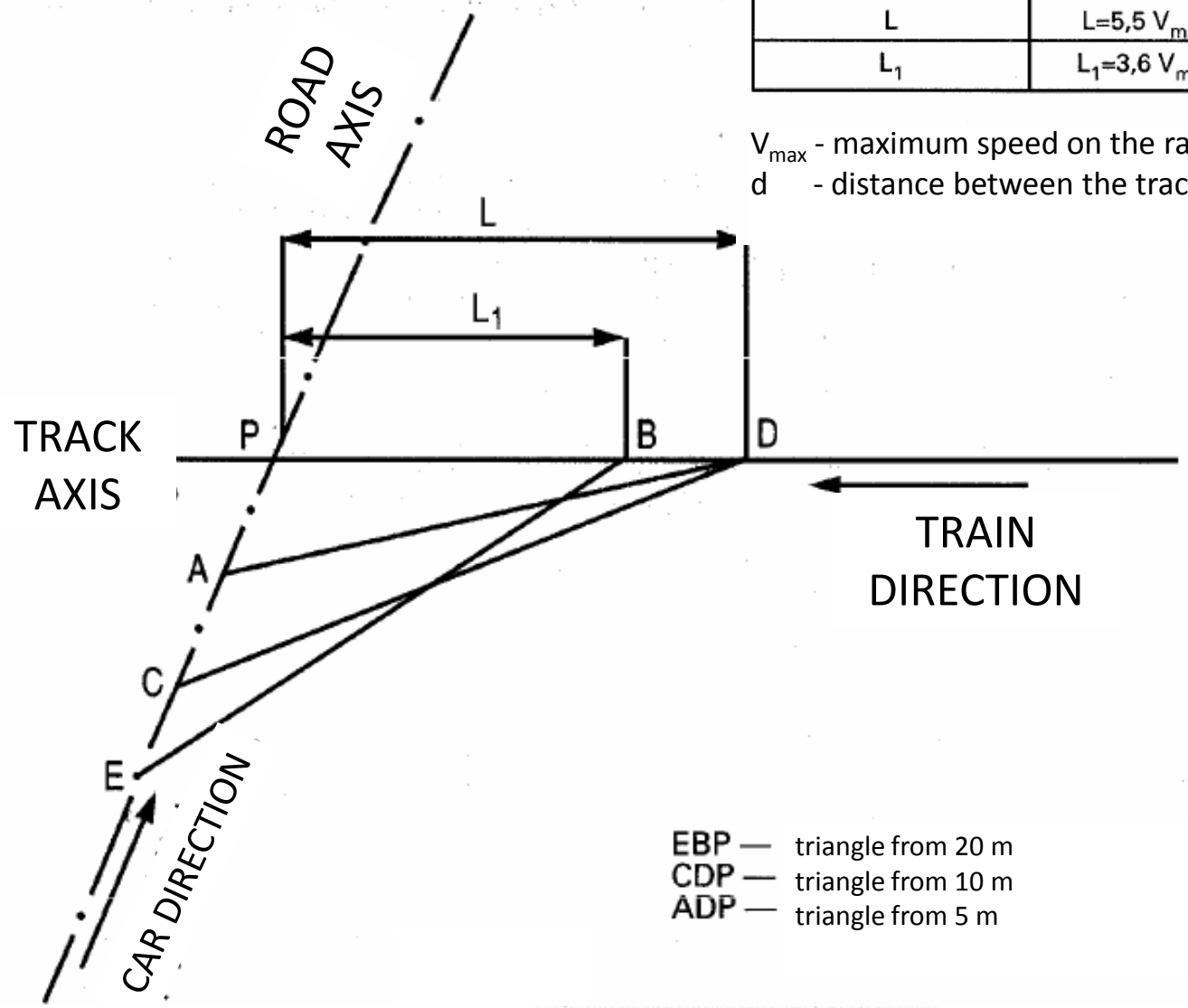
Remarks on design of grade crossing

1. In the design of every new railway line it shouldn't be more than 1 grade crossing per 3 km and overhead crossings are preferred.
2. The track and the road shouldn't cross each other under the angle more narrow than 60°, due to visibility issues.
3. The zone of the grade crossing should be properly lighted up.
4. The type of safety equipment on the crossing depends on the category of road, the speeds and so called „product of traffic" calculated on the base of the number of all rail and road vehicles crossing the zone.
5. Joints of the rails are forbidden on the length of the grade crossing.

Visibility triangles

Distance	Passage across:	
	Single track line	Double track line
L	$L=5,5\ V_{max}$	$L=(5,5+0,25d)\ V_{max}$
L_1	$L_1=3,6\ V_{max}$	$L_1=(3,6+0,07d)\ V_{max}$

V_{max} - maximum speed on the railway line [km/h]
d - distance between the tracks [m]



EBP — triangle from 20 m
CDP — triangle from 10 m
ADP — triangle from 5 m

Ballast stabilization



During passage with high speed loose particles and even pieces of the gravel are risen and can seriously damage the carriage

Ballast stabilization



Special stabilization mats made of rubber can be used to keep the ballast in position (example from Japan high speed line).

Ballast stabilization



Stabilization of the ballast by means of injection of polyurethane foam in between the sleepers

Ballast stabilization



Stabilization of the ballast by means of resin spray application on the upper surface