RAILWAYS

Special track

1. Slab track
2. Track on bridges

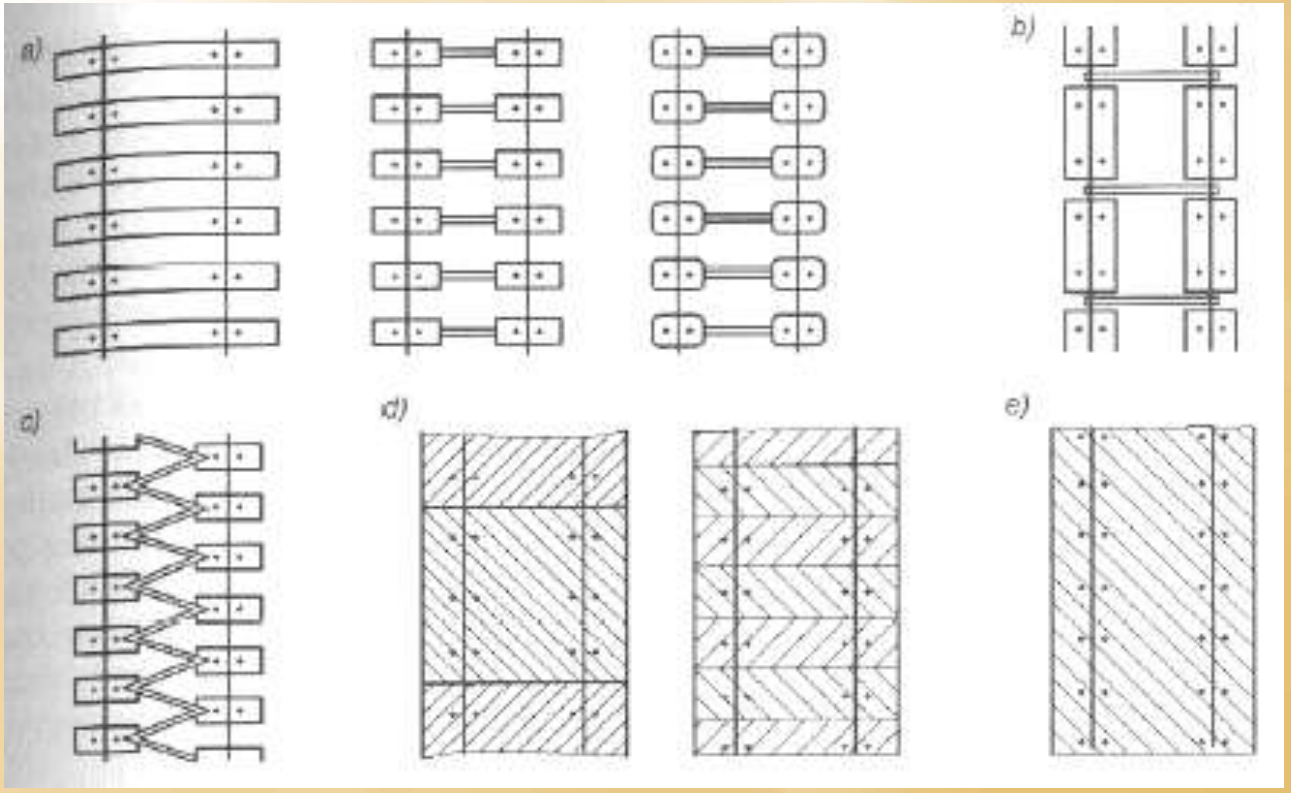


Jarosław Zwolski, PhD CE

Track without ballast

Genesis

1. Requirement of plastic deformation elimination in track.
2. Elimination of the ballast layer as the most flexible element of the classical pavement (and delimitation of the maintenance costs).
3. Increase of transversal stiffness ot the track.

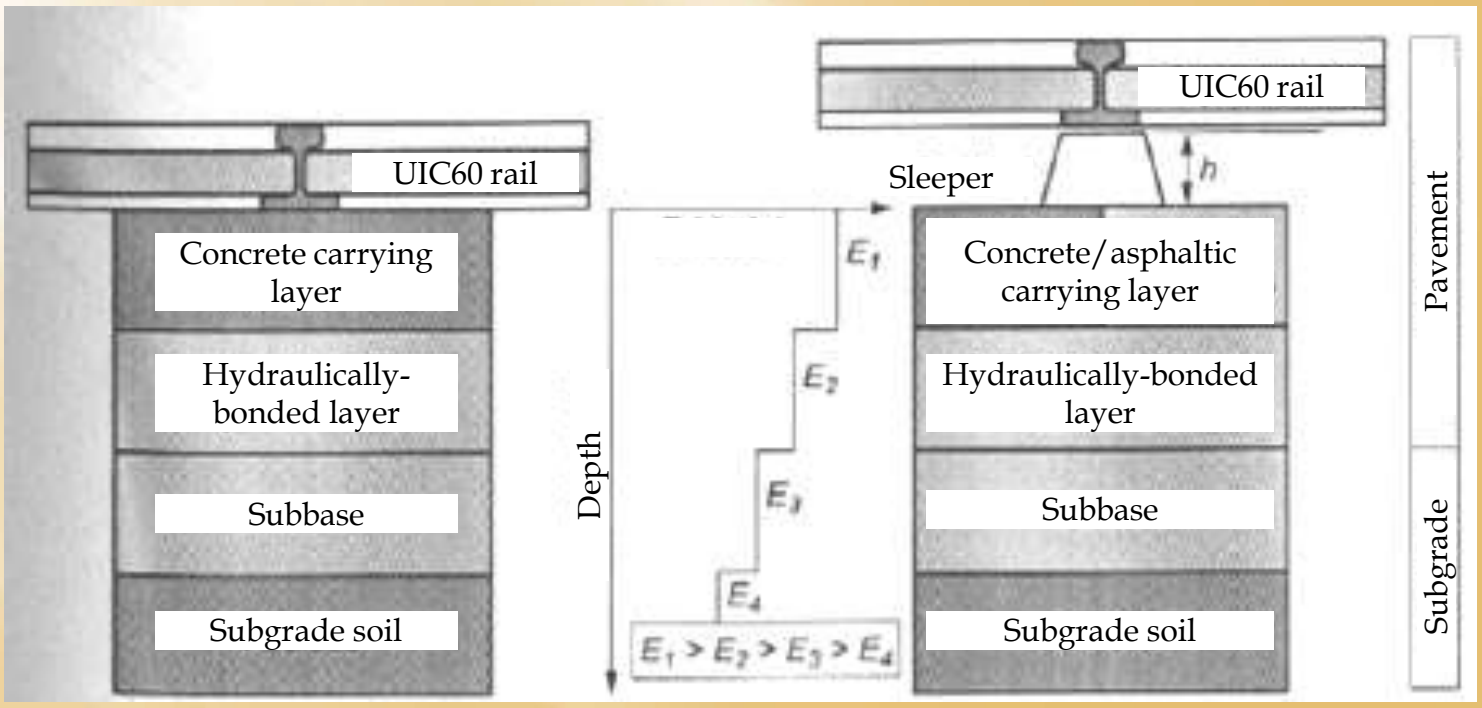


Stages of the development:
a) classical & block sleepers,
b) longitudinal block sleepers,
c) „zigzac" sleepers,
d) concrete slabs of different dimensions,
e) continuous monolithic concrete slab

Ballastless track

The idea

1. A multi-layer system with diverse elasticity moduli.
2. The lower layer the lower stiffness it has (the loads spread).
3. Methods of design are the same as in road engineering (CBR standard, ground elasticity module etc.).



Ballast track application

Application of the ballastless track:

1. On grade crossing
2. On stations (the track at the platforms)
3. In tunnels and bridges
4. Tramway trackr on the traways shared with road traffic
5. On lines (West Europe, Asia)

REMARKS:

1. The loads from rails are transferred on the concrete slab and then on the reinforced and dewatered subgrade.
2. The rails can be supported point-wise (like in a classic track) or line-wise, using another fastening method.
3. Very often the fastening system provides also some vibration- and noise-damping elements.
4. The ballastless track is sensitive on uneven subgrade settlement (difficult diagnosis and retrofitting).
5. Doesn't need maintenence (tamping).

Pros and cons

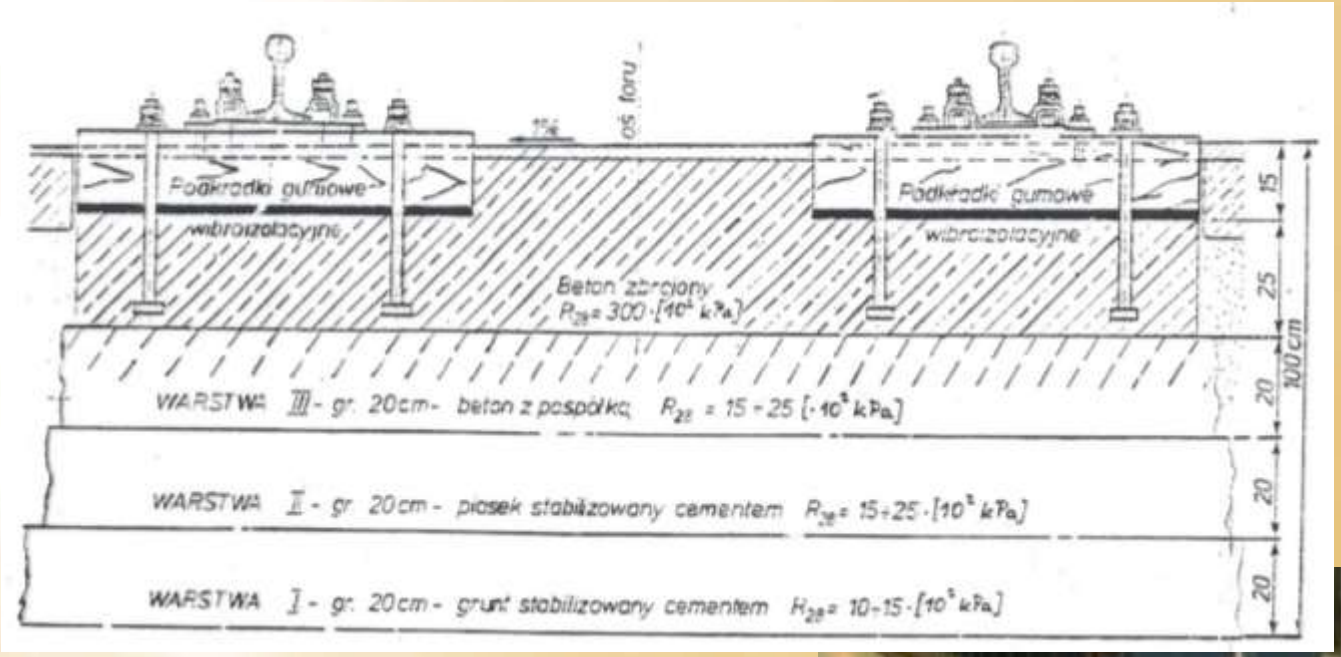
Advantages

- Good damping properties
- Low noise emission
- Fast building process
- Easy maintenance (doesn't need tamping of the ballast)
- Easy dewatering
- Low height of the pavement
- Low weight of the pavement
- High precision of the rails rectification
- Long life (ca. 30 years and more)
- No geometry deformation under normal conditions

Disadvantages

- High price of the design, building and retrofitting (in case of …..)
- Needs careful maintenance of the soft elements
- Complicated structure
- Short experiences of operation
- Sensitivity on uneven subgrade settlement

Ballastless track-station



1. Ballastless pavement of tracks on the Central Station in Warsaw.
2. Elimination of loose materials down to the depth of 1.0 m (from the rail head).



Ballastless track-station



REMARKS:

1. The track on the Akabane Station has been developed by Railway Technical Research Institute of Japan.
2. Longitudinal post-tensioned concreste sleepers of length 6.25 m are kept in the gauge by thin-walled steel pipes.
3. The track is based on transversal concrete elements with some anti-vibration pads.

Ballastless track-tunnel



1. The Brandleite Tunnel.
2. GETRAC® A3 system. The concrete sleepers are based on specially prepared asphalt layer. The horizontal forces are carried by concrete anchors.

Ballastless track-tramway

a)



b)



1. a) Chur, Switzerland and b) Drezno, Niemcy.
2. System Rheda City

Ballastless track-line

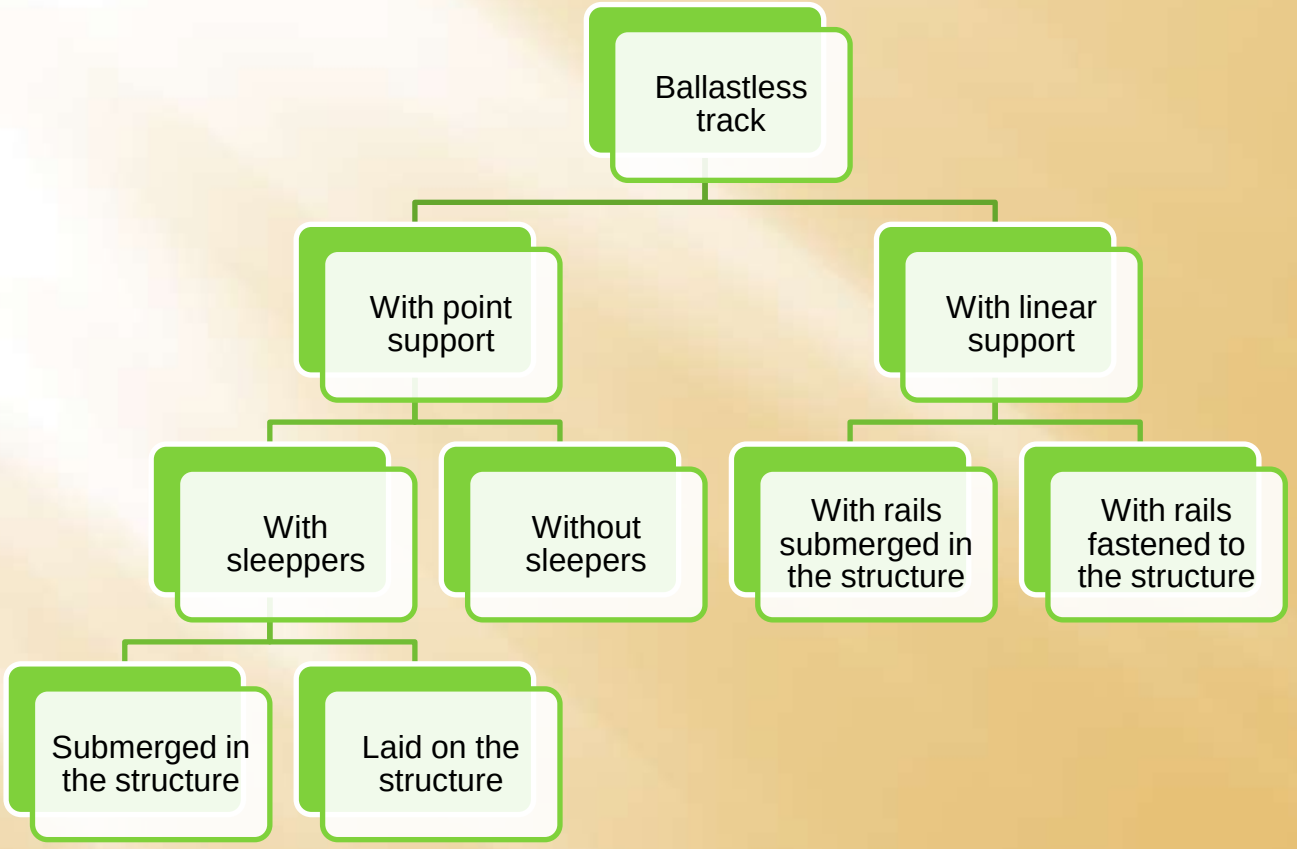


Ballastless track of High Speed Line in China



Ballastless track of RHEDA 2000® system for High Speed Line in Tajwanie.

Ballastless track-classification

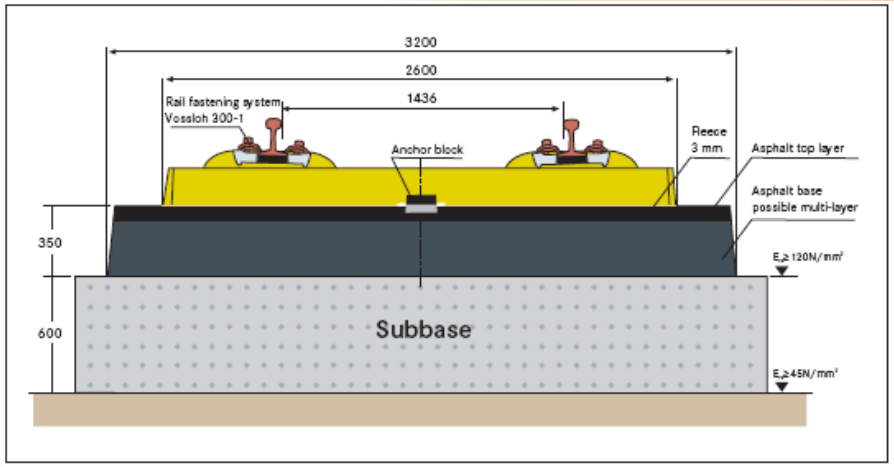


The most important suppliers:

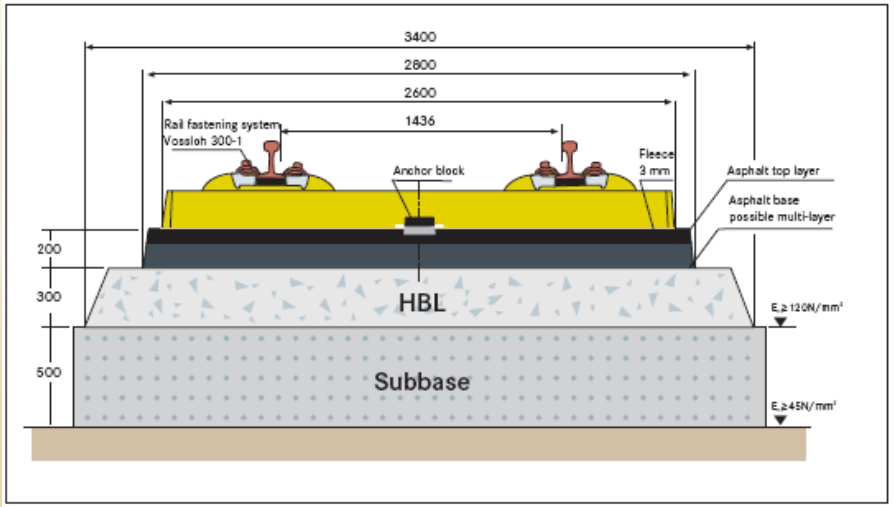
- GETRAC
- RHEDA 2000
- EDILON
- ZÜBLIN
- SONNEVILLE
- MAX BÖGL
- HEITCAMP
- CDM
- Leonhard Weiss

The technologies can involve casting in situ or using precast elements.

GETRACK



System cross-section without HBL ($E_{V2} \geq 120$ mm²)



System cross-section with HBL ($E_{V2} \geq 120$ mm²)

Scheme of layers

HBL - hydraulically-bonded layer – a layer of soil mixed with water and cement for increase its strength and time stability

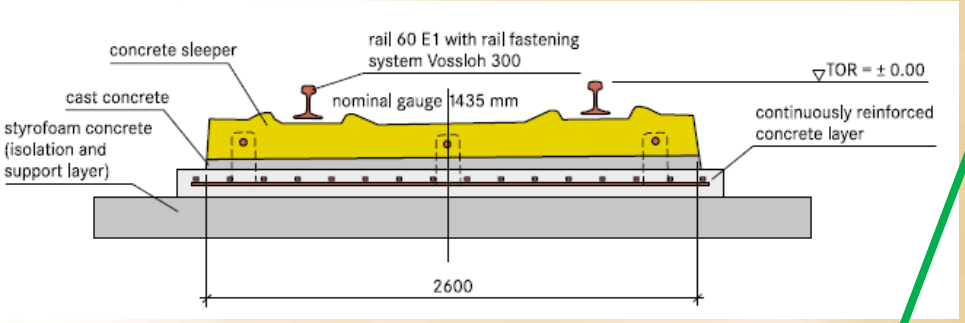


The finished track

http://www.railone.com/

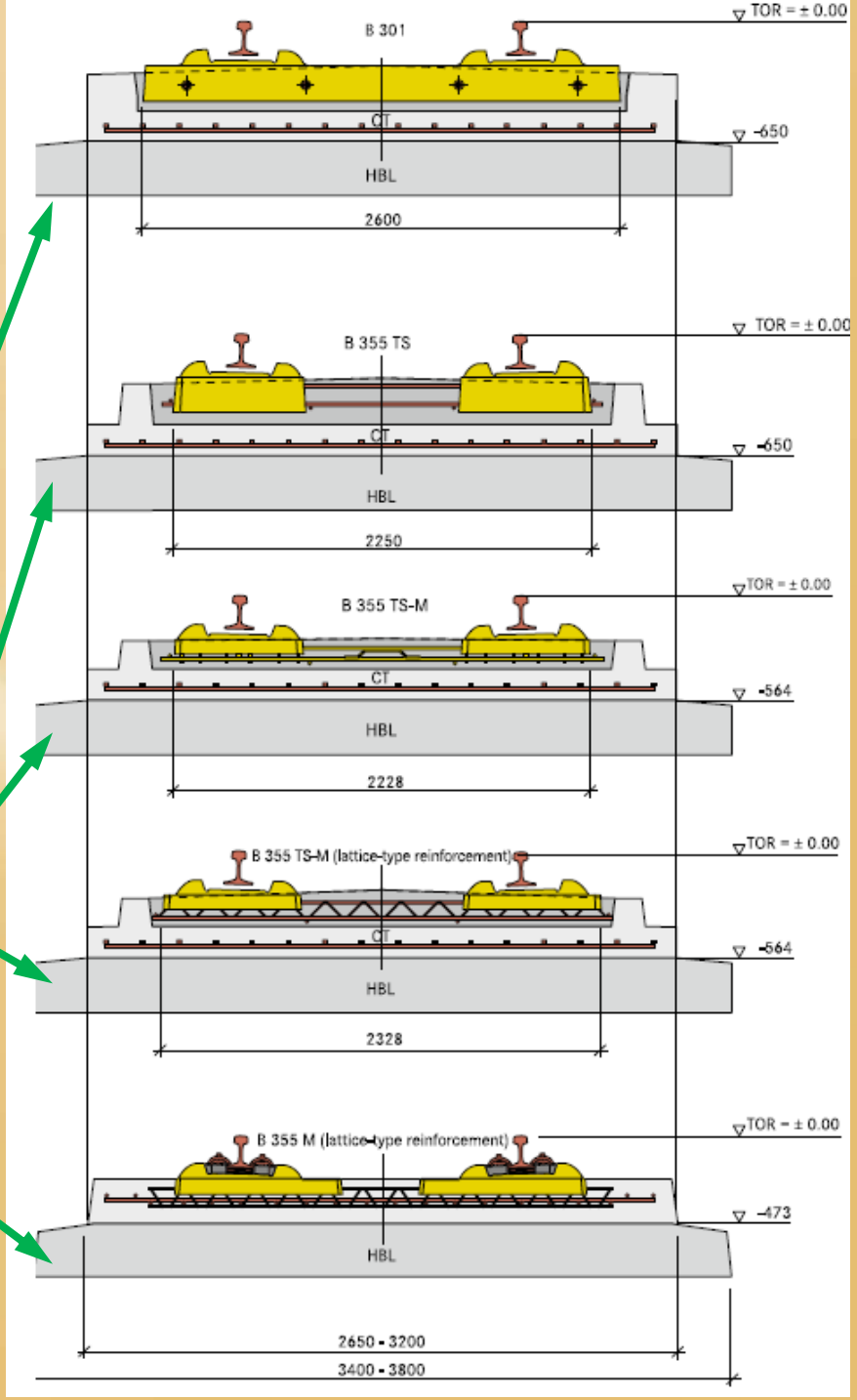
RHEDA

http://www.railone.com/

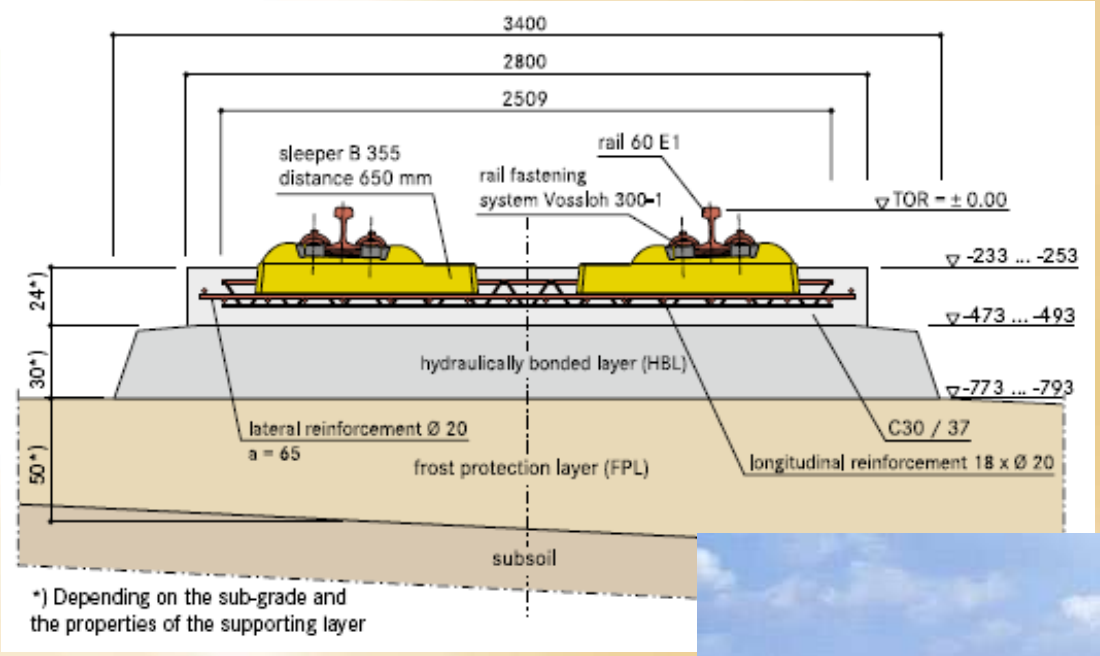


RHEDA (Classic)

RHEDA (Sengeberg)
RHEDA-Berlin HST –V1
RHEDA-Berlin HST –V2
RHEDA-Berlin HST –V3
RHEDA 2000



RHEDA 2000



Scheme of layers

FPL – frost protection layer – usually made of compacted permeable soil

The finished double track line



RHEDA 2000

PREPARATION OF THE SUBSTRUCTURE



Embankment

- Placing of the frost protection layer using conventional construction machines
- Placing of the hydraulically bonded layer using conventional construction machines



Civil structures

- Preparation of the civil structure surface and the possible track fixation elements according to the individual sub-/superstructure design

ASSEMBLY OF THE TRACK PANEL



Assembly on site

- Placing reinforcement
- Placing of single sleepers and installation of track reinforcement
- Installation of rails (temporary or final)



Pre-assembly

- Pre-assembly of the track panels on special sites
- Transport and placing of the complete track panels to the final installation location

ROUGH ALIGNMENT OF THE TRACK PANEL



Manual rough alignment

- Lifting and rough alignment of the track panel using manual devices (rail jacks, track alignment frames, etc.) and survey instruments



Automatic rough alignment

- Lifting and rough alignment of the track panel using automatic devices: e.g., rough alignment machines, remotely controlled by electronic surveying instruments

INSTALLATION OF THE TRACK FORMWORK

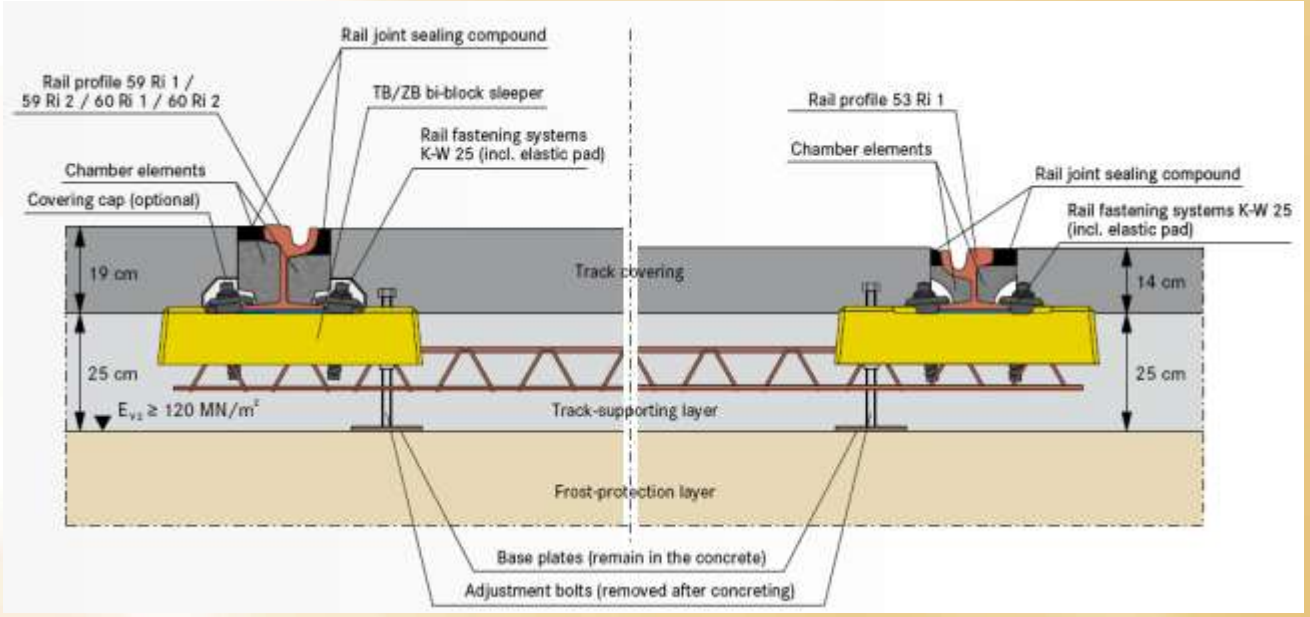


Possible kinds of formwork

- Individually / manually (on site) manufactured formwork (e.g., timber formwork)
- Pre-fabricated formwork system elements (usually of steel)
- Pre-fabricated (steel) formwork system elements with integrated rails for construction vehicles

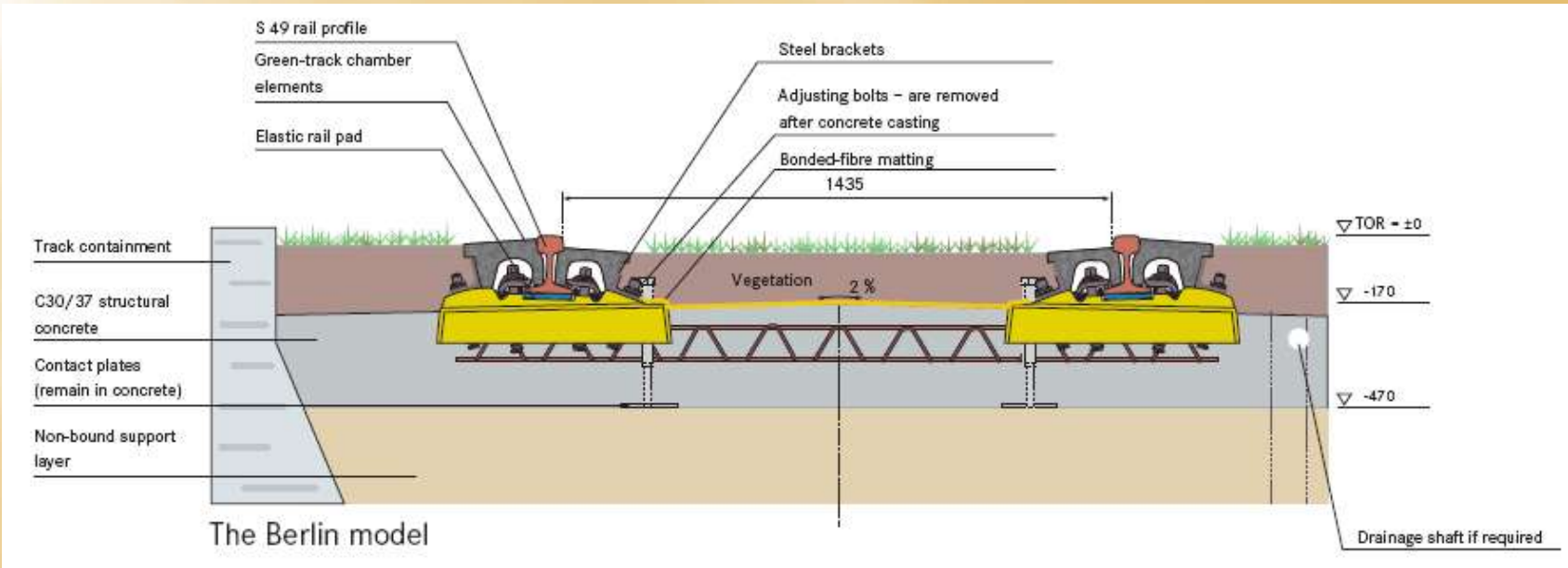


RHEDA CITY



Rheda City

Rheda City Green



The Berlin model

RHEDA CITY









The sleepers distance equals to 75 cm

RHEDA CITY

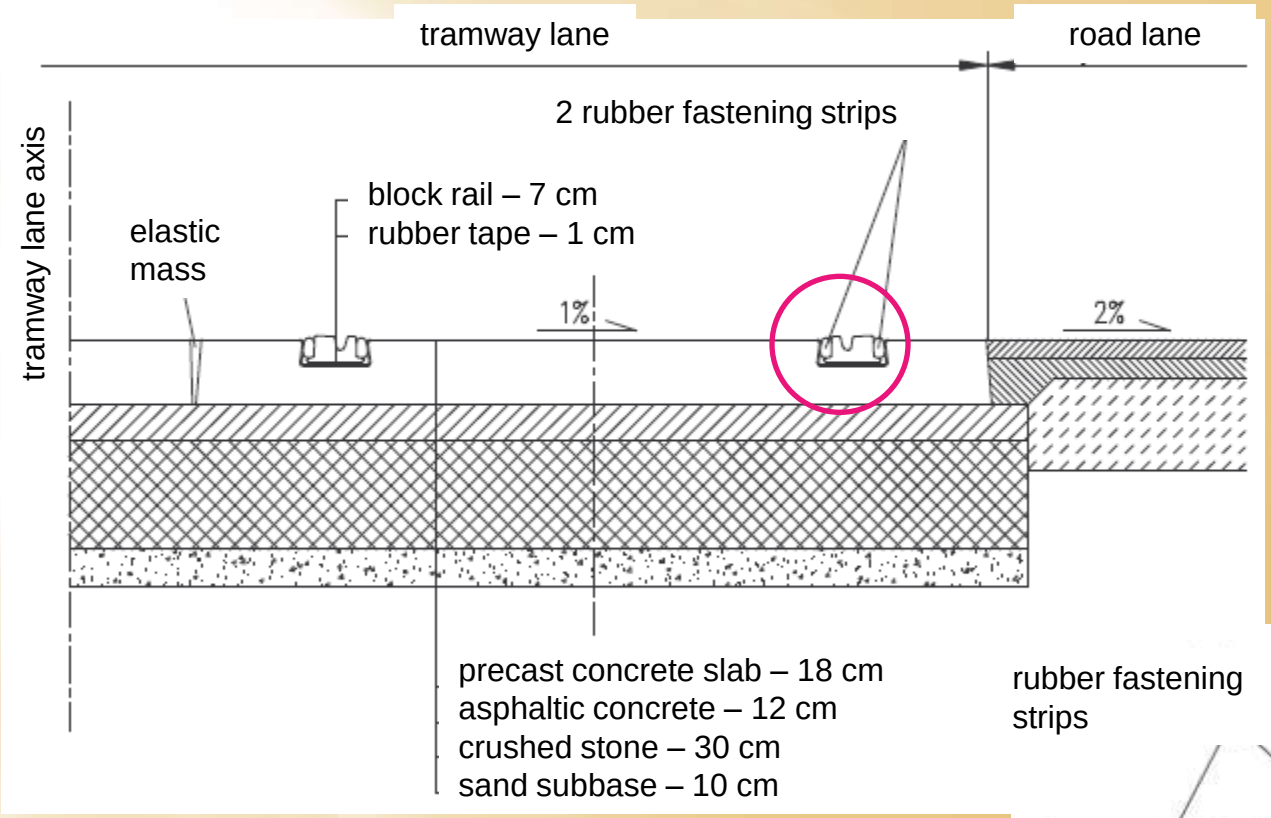


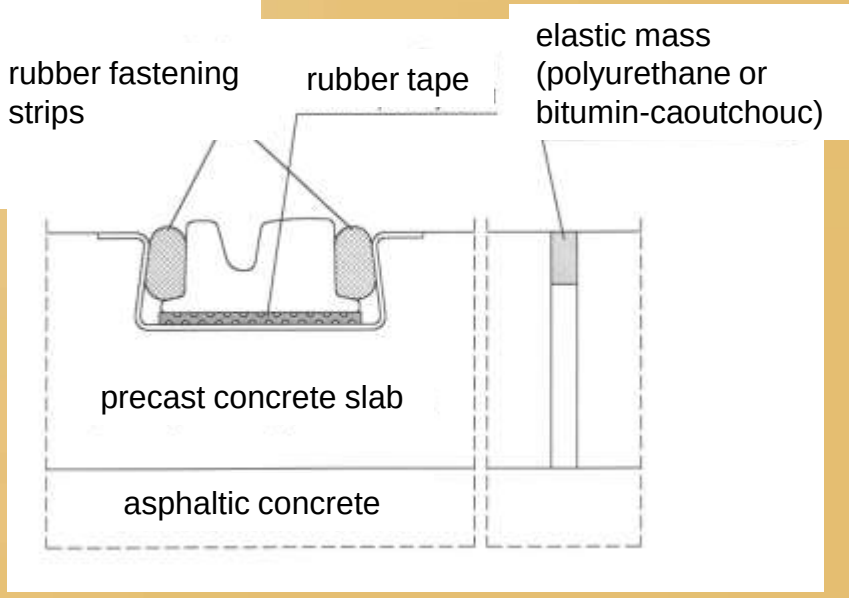




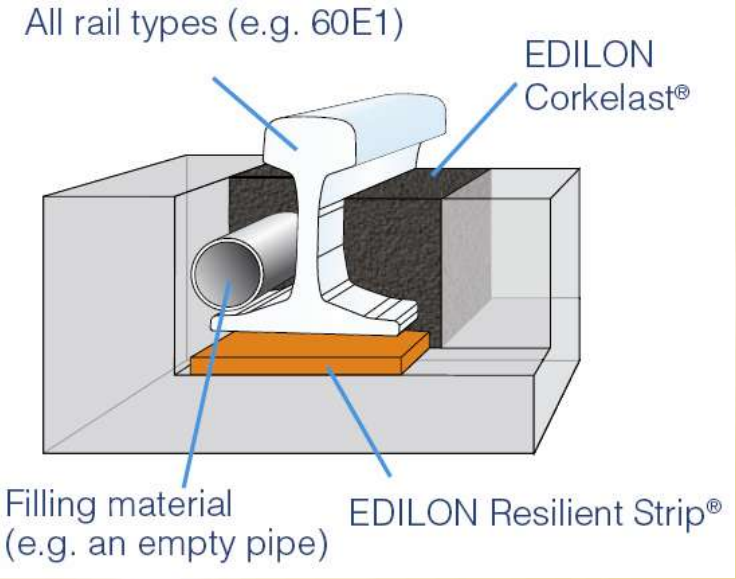


So called Hungarian track

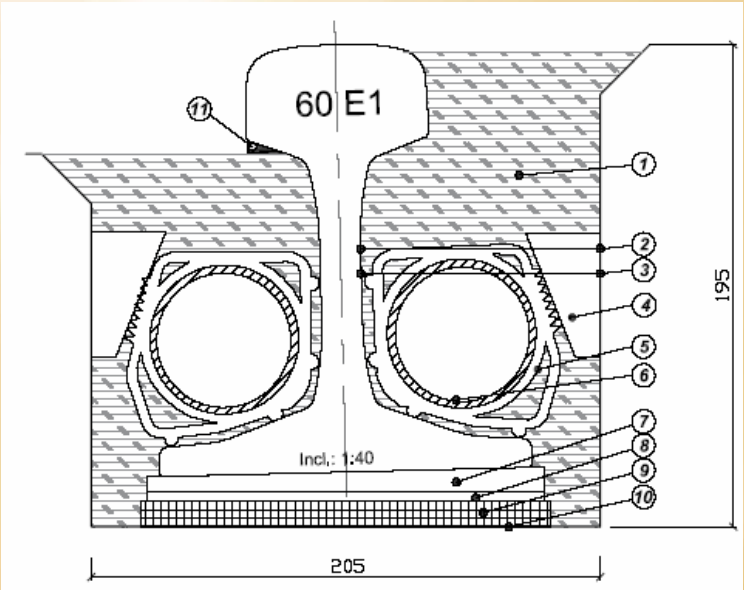


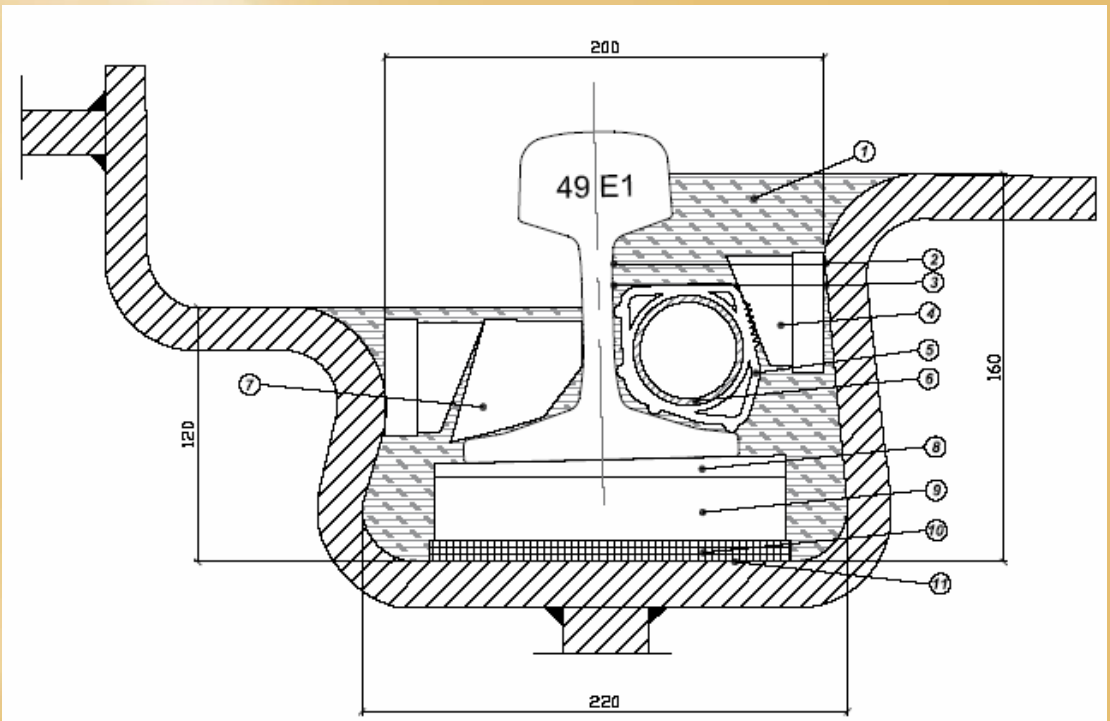


EDILON ERS (Embedded Rail System)

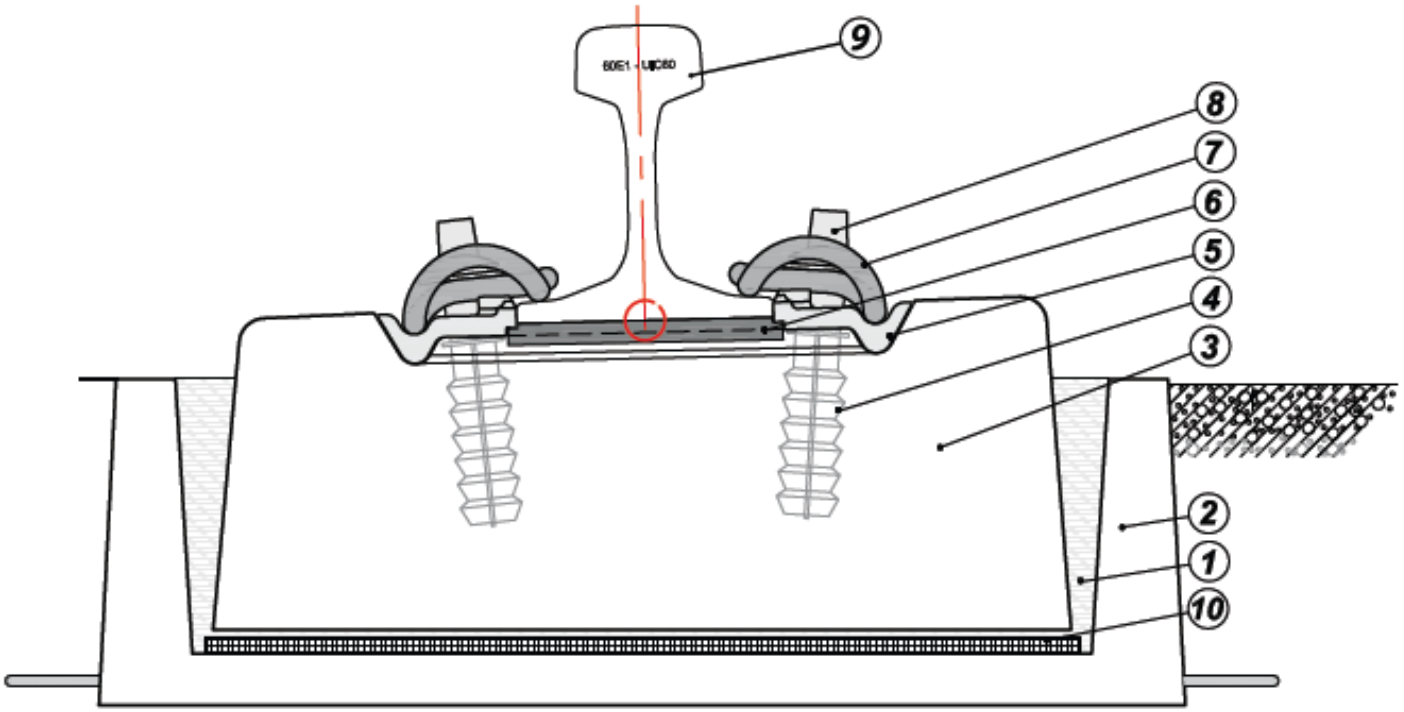


Precast or cast-in-situ concrete slab with two channels for rails or a deck structure shaped with steel channels. The rails are fastened in the channels by means of Edilon Corkelast® mass based on polyurethane resin and it is linearly supported by the anti-vibration pad called Edilon Resilient Strip.





EDILON EBS (Embedded Block System)

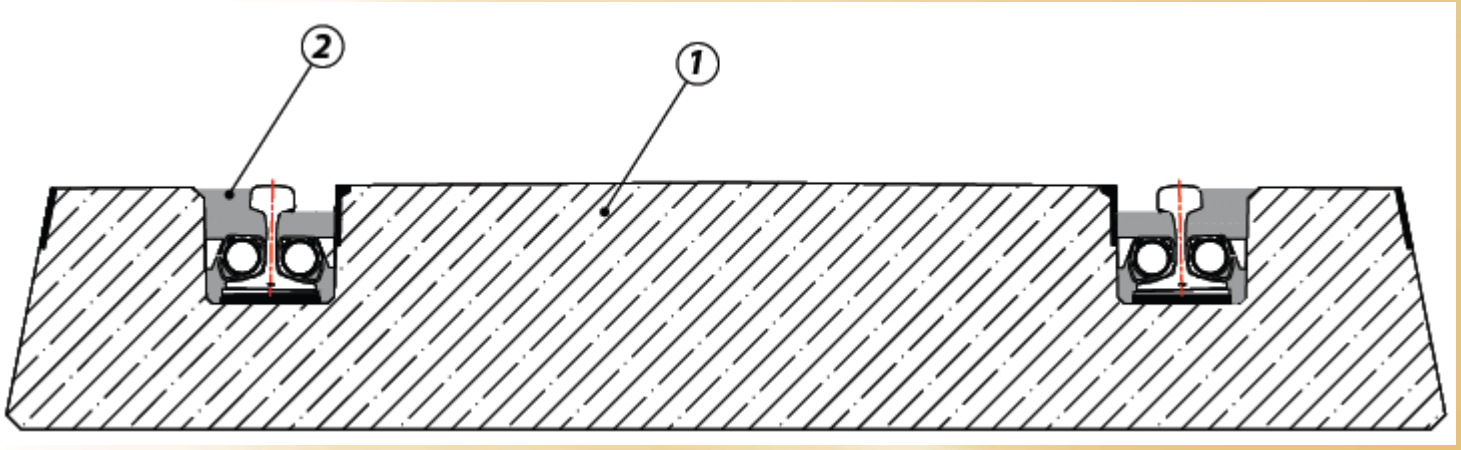


Embedded Block System – with precast concrete box

1. coating of the supporting block - Edilon Corkelast mass, 2. precast concrete box, 3. concrete supporting block, 4. PE coating tube, 5. fastening steel pad, 6. sub-rail pad, 7. elastic clip, 8. screw, 9. rail, 10. anti-vibration pad – Edilon Resilient Strip

The rails are fastened by separate supporting blocks embedded in precast box (concrete, composite or steel) by means of the elastic mass Edilon Corkelast.

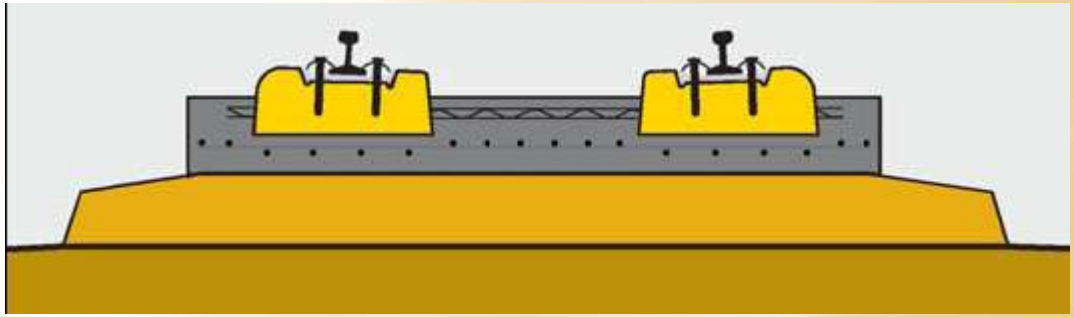
EDILON LCL (Level Crossing)



The prepared substructure
1. The soil compacted up to the module E_2>45 MPa.
2. Layer of thickness 37 cm made of crushed stone with granularity 0/31,5 mm and compacted up to module E_2>120 MPa.
3. Levelling course made of coarse grit or light concrete.



ZÜBLIN

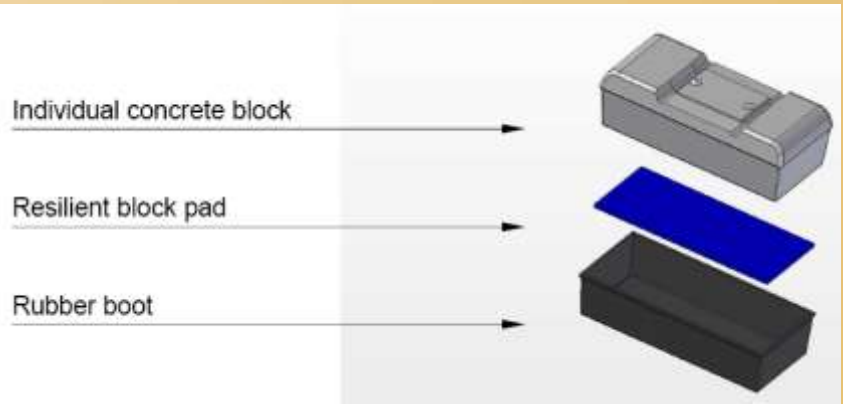


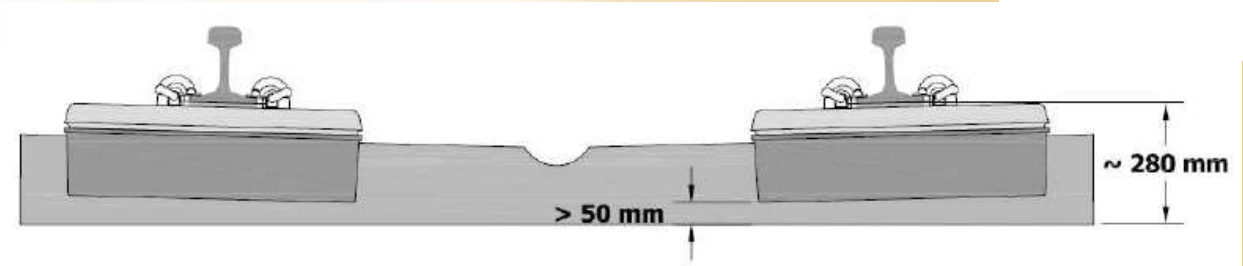






SONNEVILLE







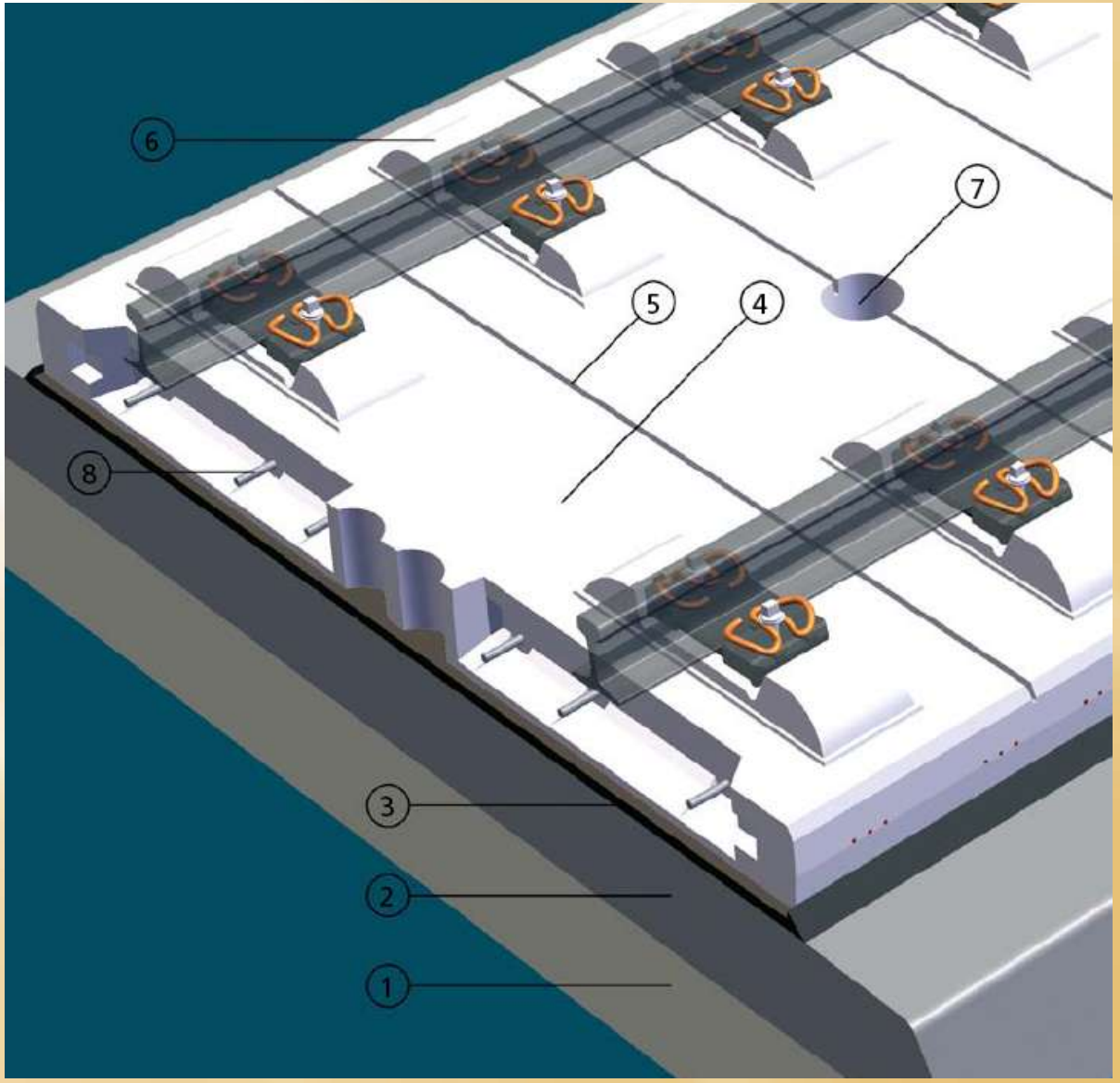
Track assembling in a tunnel



The finished track

http://www.sonneville.com/

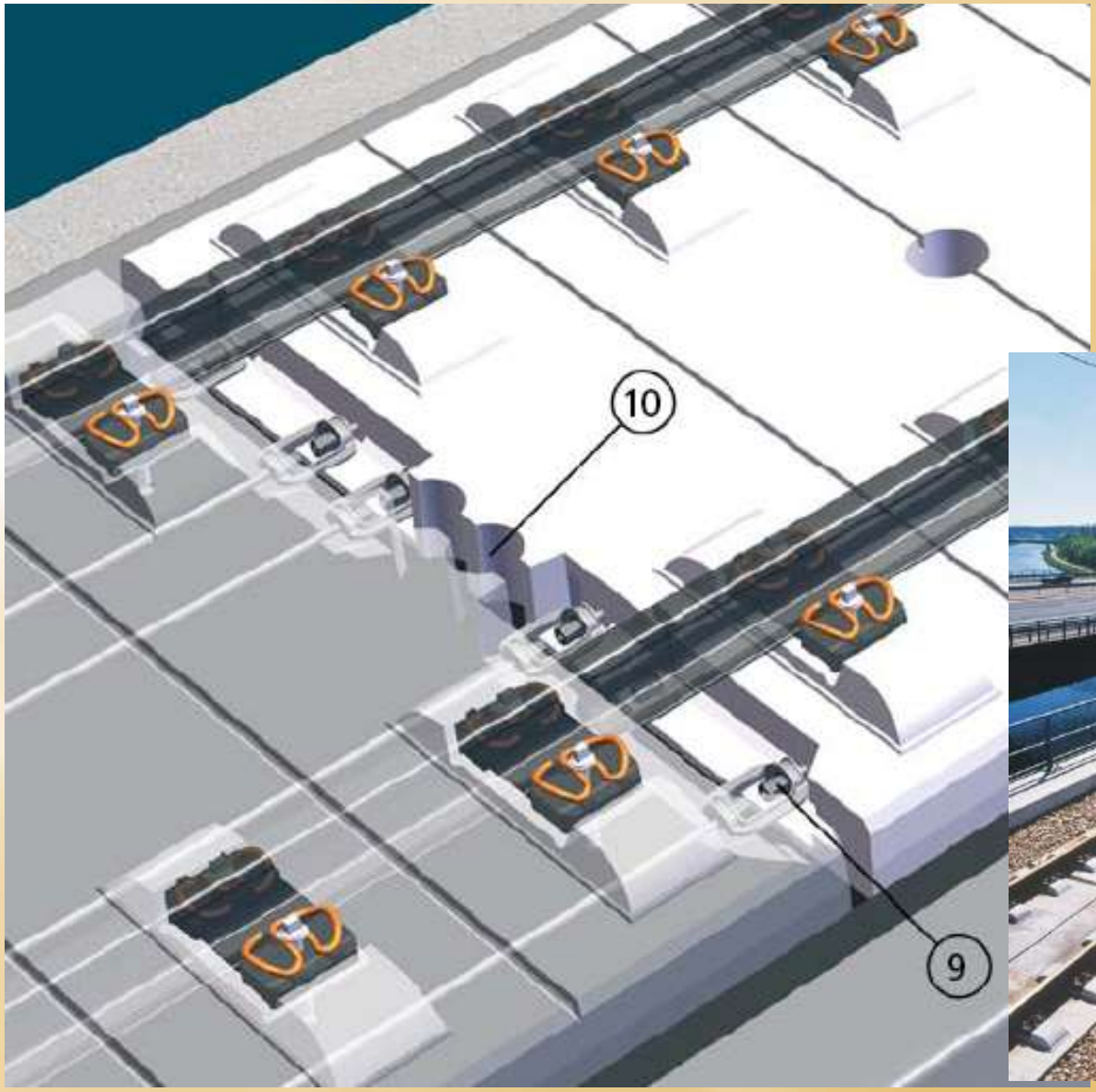
MAX BÖGL



1. frost-protection layer
2. hydraulically bonded layer, d=30 cm
3. levelling course (mortar)
4. concrete slab, prestressed or reinforced by steel fibre (6.50 x 2.25 x 0.20 m)
5. dilatation slot
6. fastening elements
7. an opening for the mortar to flow out
8. connectors to the following slab

http://www.max-boegl.de

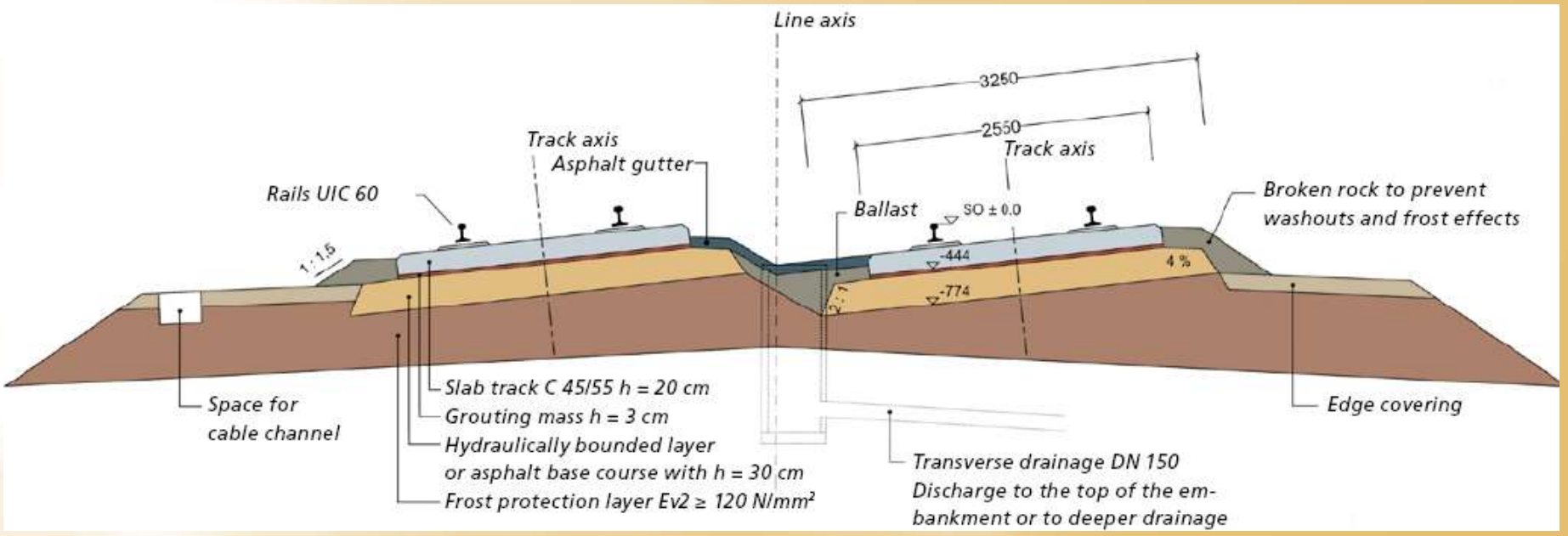
MAX BÖGL

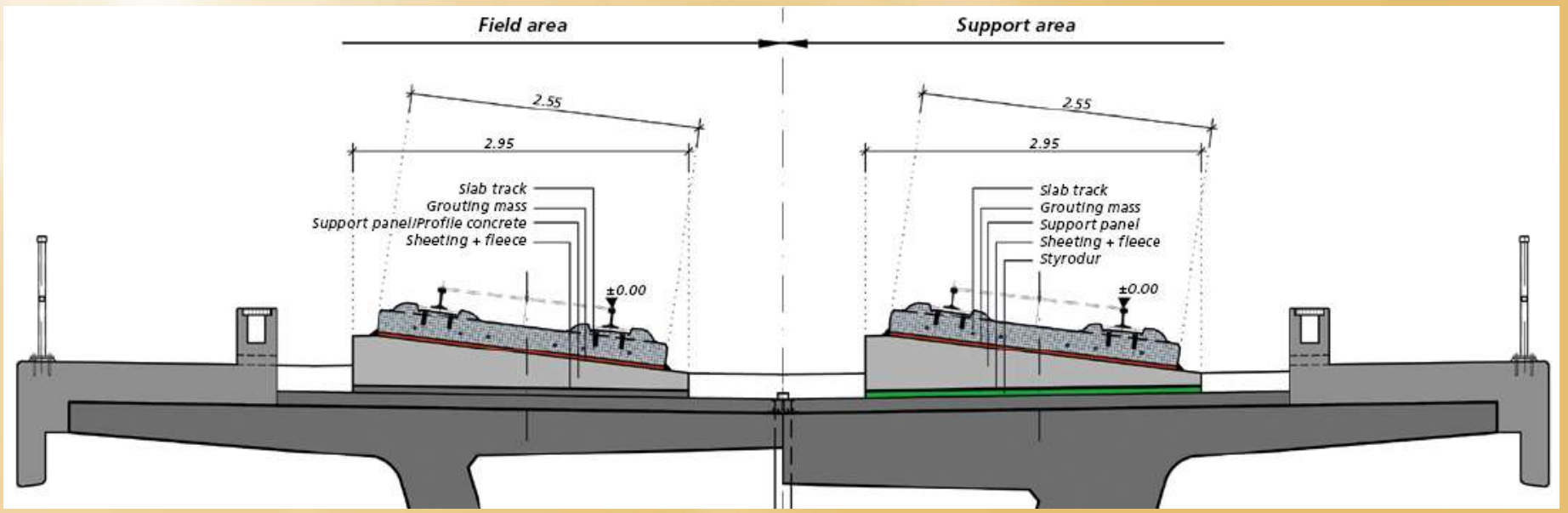


9. connectors for joining the following slab
10. dilatation space

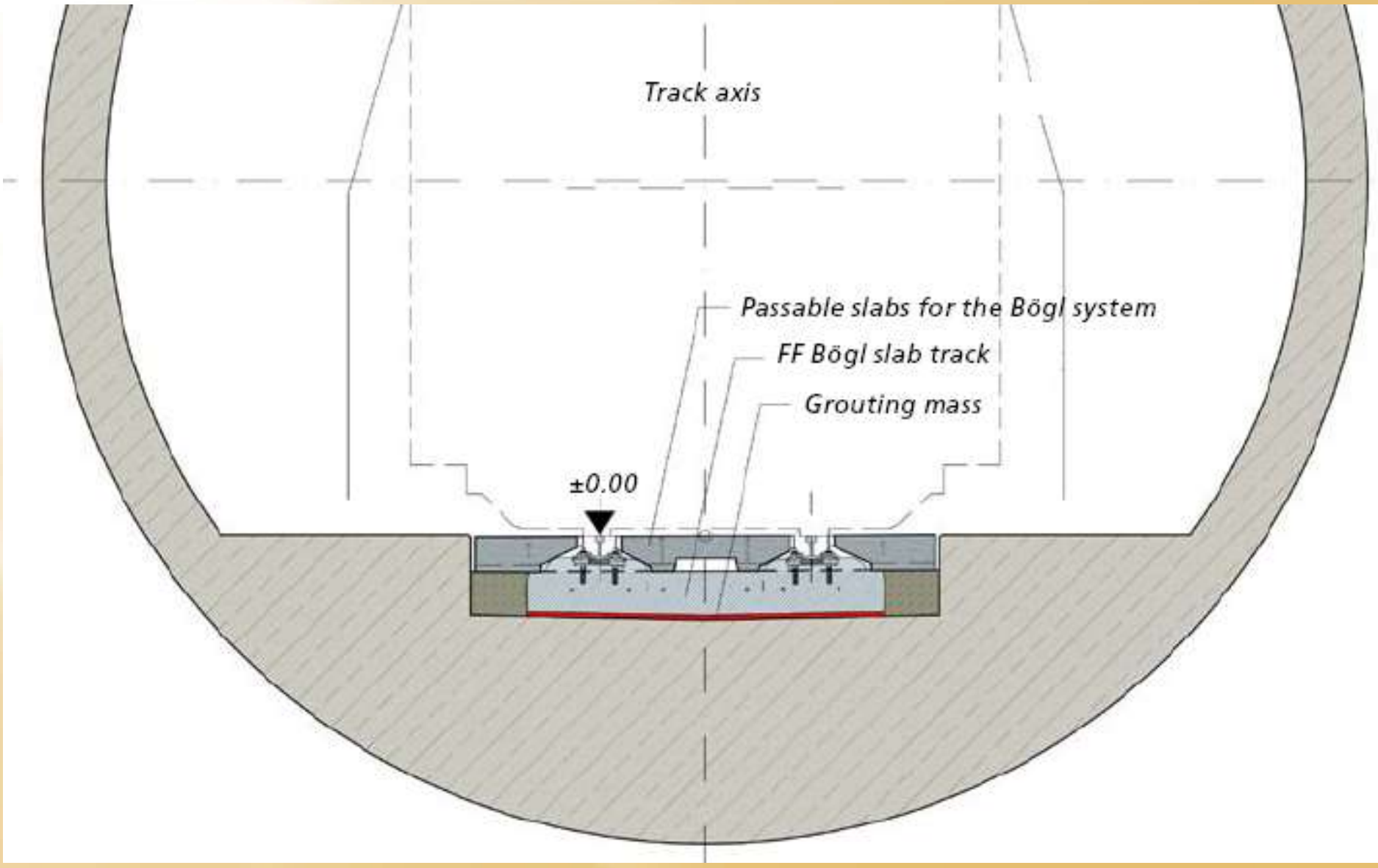


MAX BÖGL


Line axis
3250
2550
Track axis
Track axis
Asphalt gutter
Rails UIC 60
Ballast
SO ± 0.0
Broken rock to prevent
washouts and frost effects
1:1.5
-444
-774
4 %
2 : 1
Space for
cable channel
Slab track C 45/55 h = 20 cm
Grouting mass h = 3 cm
Hydraulically bounded layer
or asphalt base course with h = 30 cm
Frost protection layer Ev2 ≥ 120 N/mm²
Transverse drainage DN 150
Discharge to the top of the em-
bankment or to deeper drainage
Edge covering

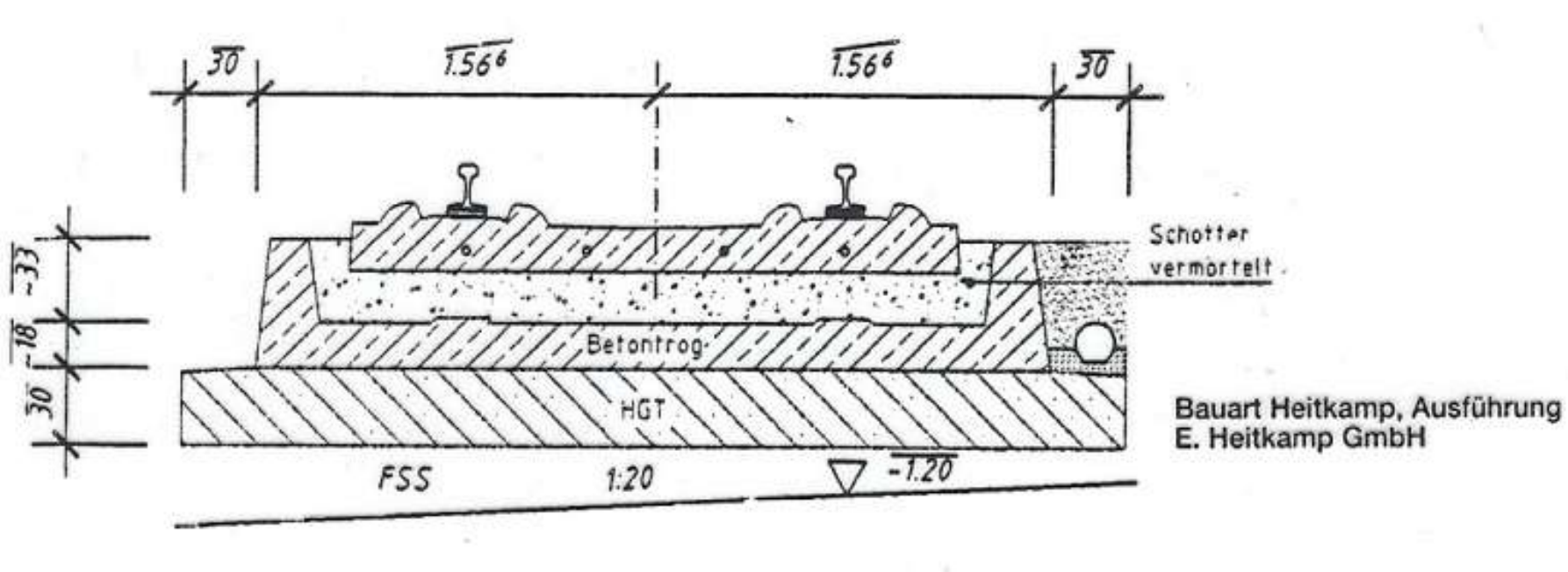

Field area
Support area
2.55
2.95
Slab track
Grouting mass
Support panel/Profile concrete
Sheeting + fleece
±0.00
2.55
2.95
Slab track
Grouting mass
Support panel
Sheeting + fleece
Styrodur
±0.00

MAX BÖGL


Track axis
Passable slabs for the Bögl system
FF Bögl slab track
Grouting mass
±0.00

http://www.heitkamp-rail.de/

HEITCAMP



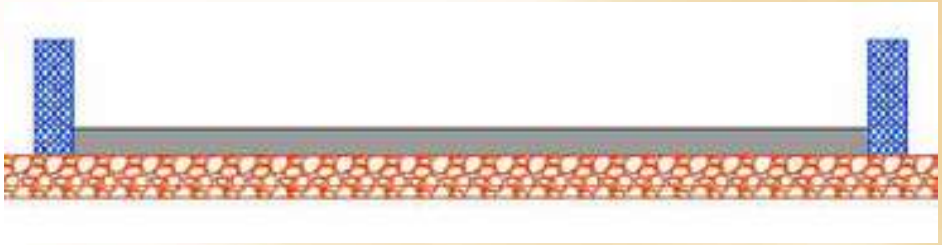
1. Building a classical ballasetd track but in a concrete trough laid on a HBL.
2. After assembling the track ladder and tamping the ballast it is filled with mortar.

CDM

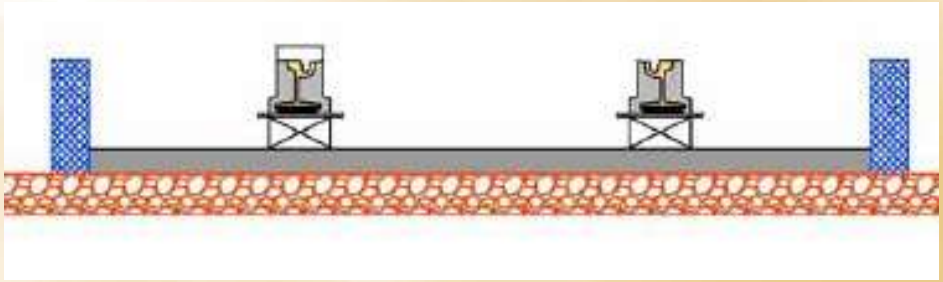


http://www.cdm.eu/

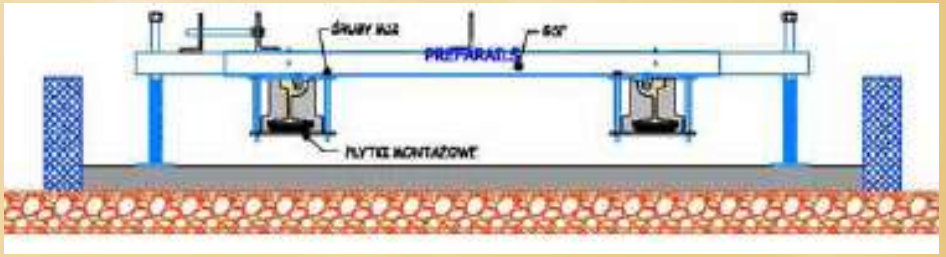
1. Pouring of light concrete layer



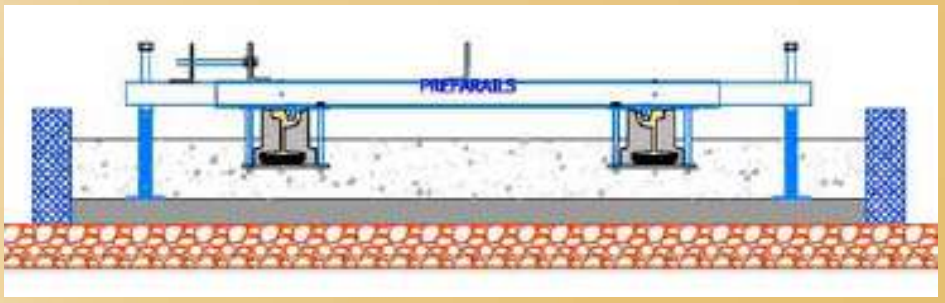
2. Placement of the rails prepared with the lining on the temporary supports in rough geometry



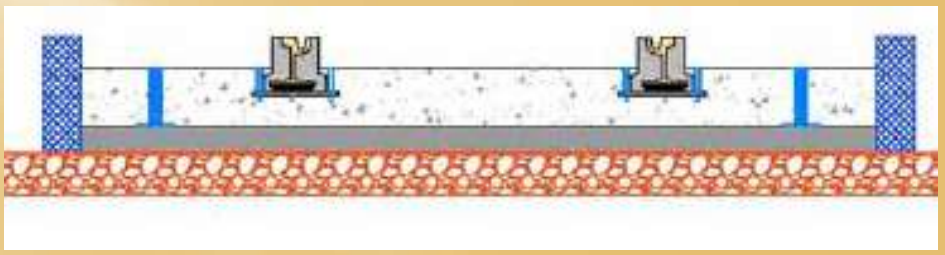
3. Placement of steel supports, hanging up the rails, welding and rectification to the final geometry



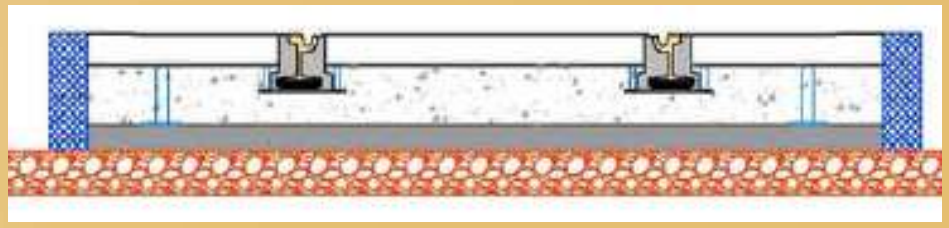
4. Placing the reinforcement and concreting



5. Disassembling of the supports



6. Finishing with the road pavement

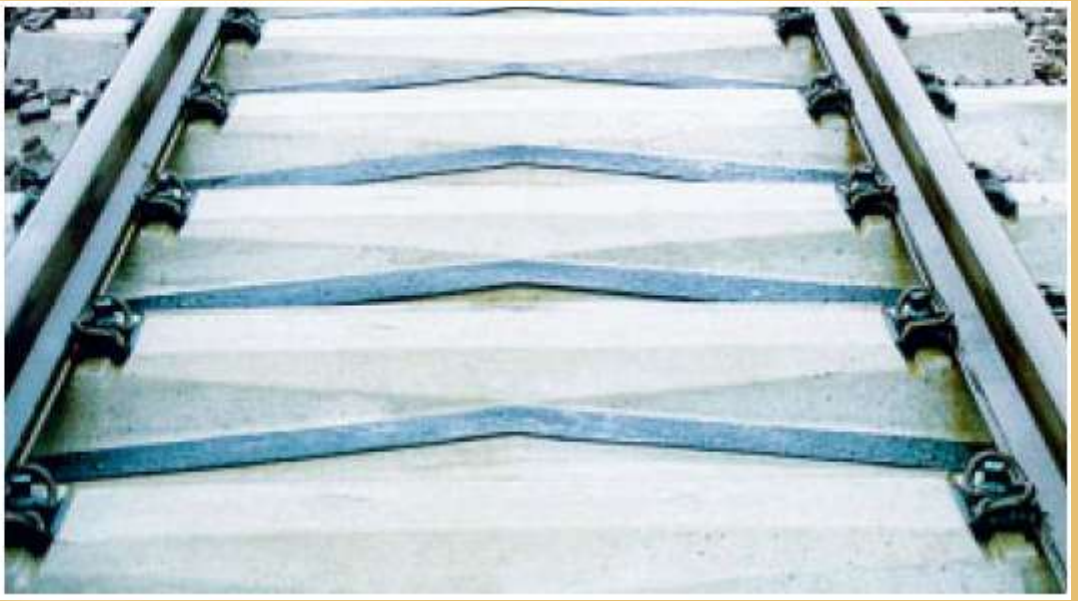


Breiteschwelle





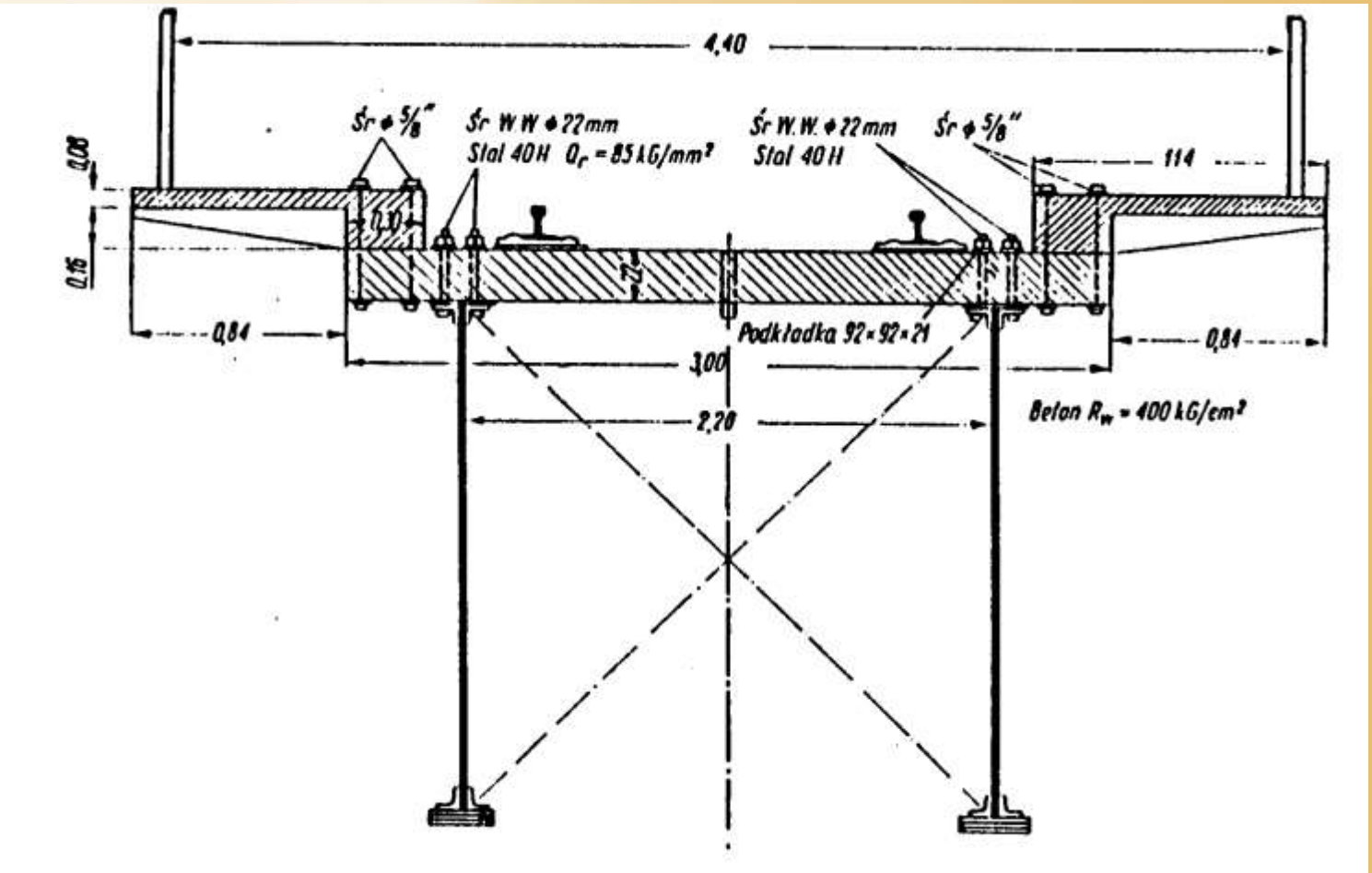




Track on bridge

1. Methods of the track placing on the bridge

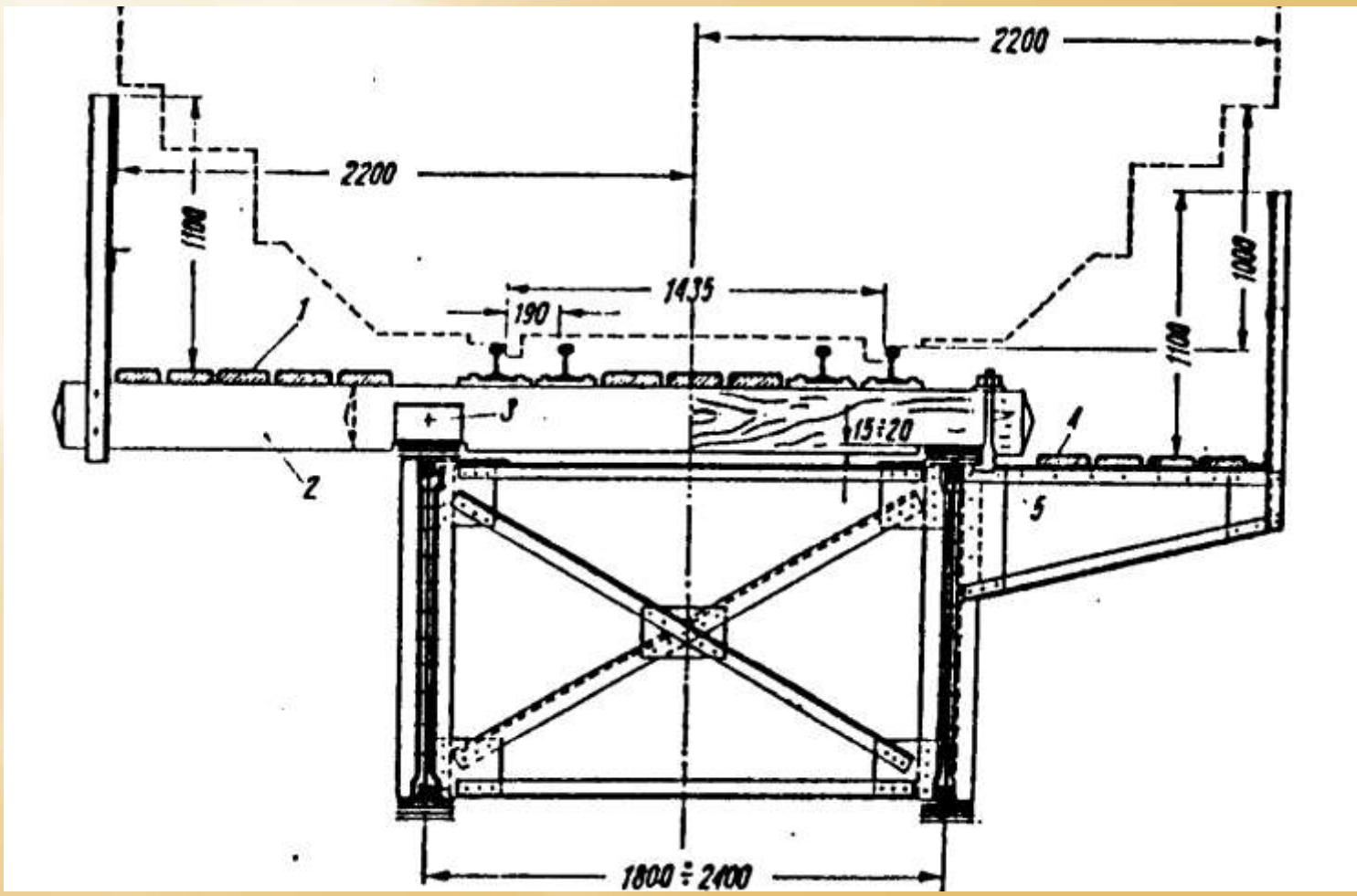
   A) Direct fastening of the rails to the structure



Track on bridge

1. Methods of the track placing on the bridge

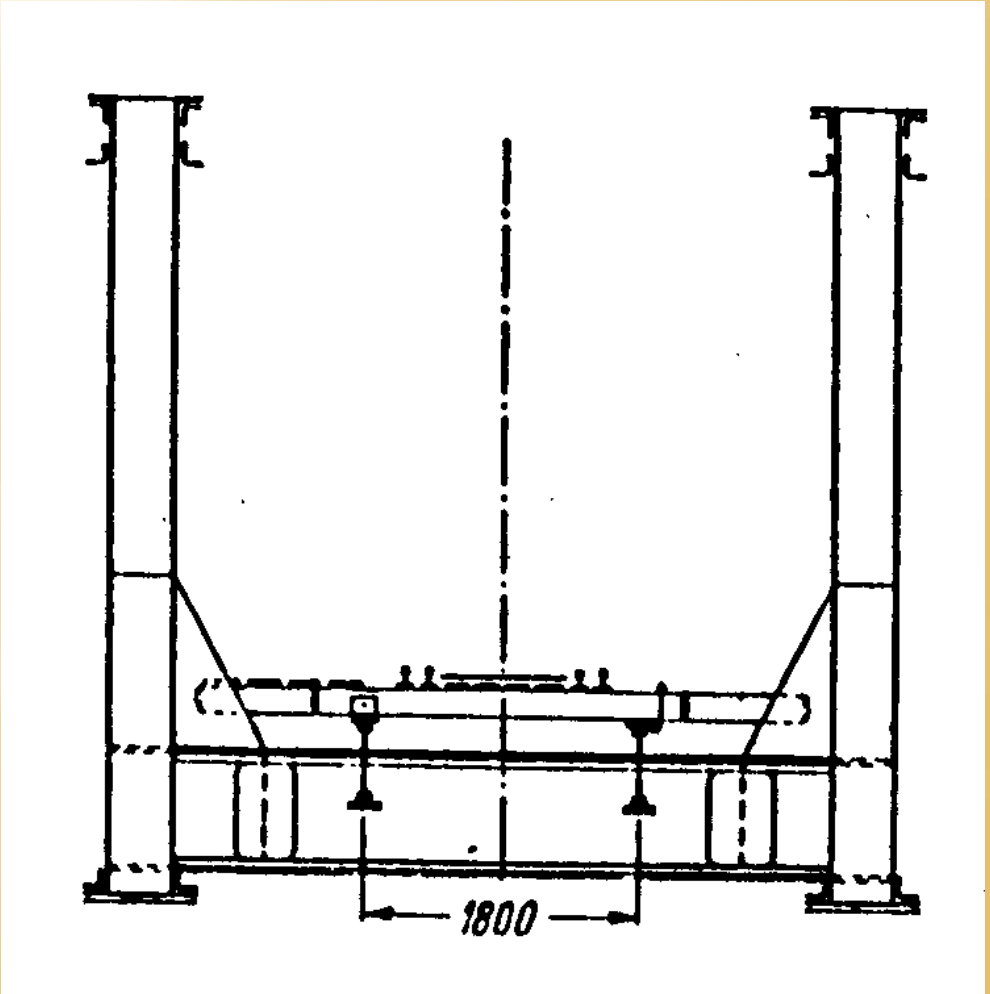
   B) Rails on sleepers supported on the main girders



Track on bridge

1. Methods of the track placing on the bridge

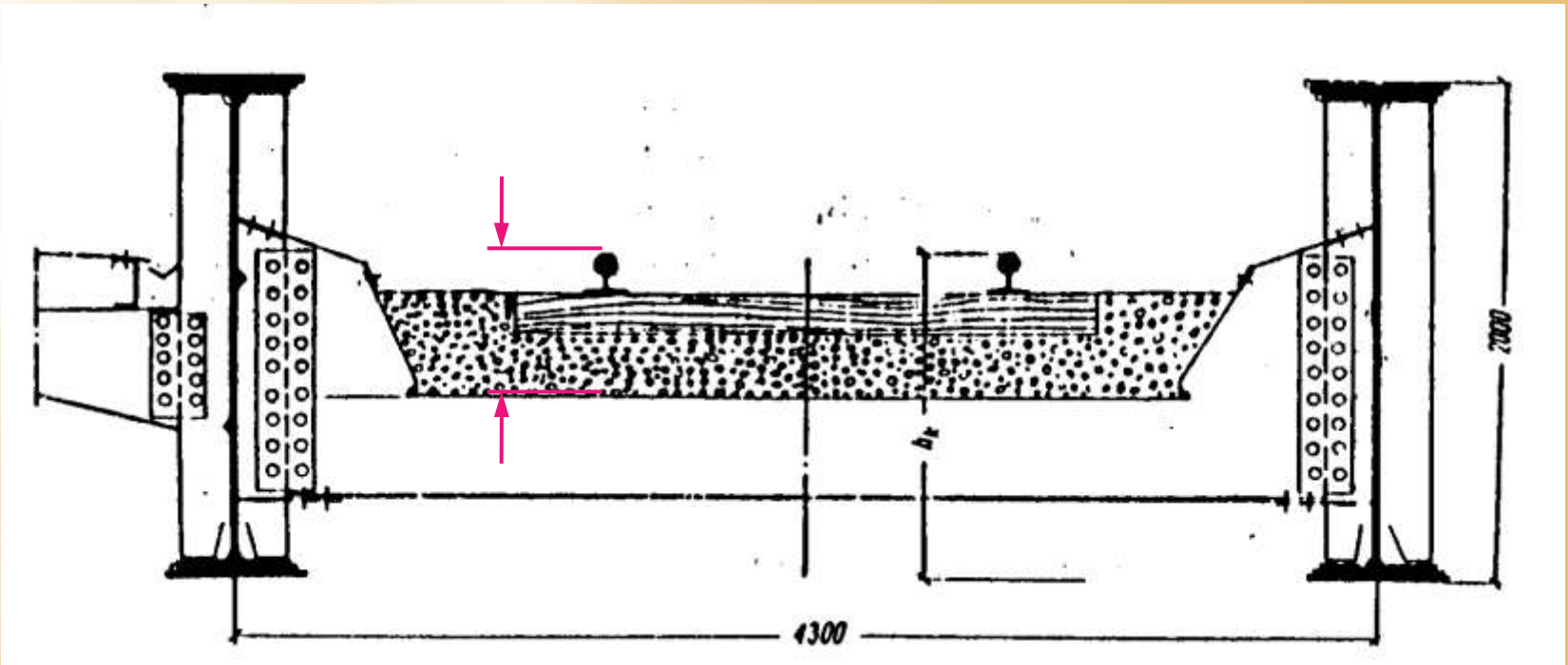
   C) Rails on sleepers supported on the stringers (longitudinal deck elements)



Track on bridge

1. Methods of the track placing on the bridge

D) Rails and sleepers with ballast layer on the dect shaped as a trough



Minimum ballast thickness together with sleeper and the rail should be 70 cm due to dynamic performance and the space for ballast cleaning machines.

Track on bridge

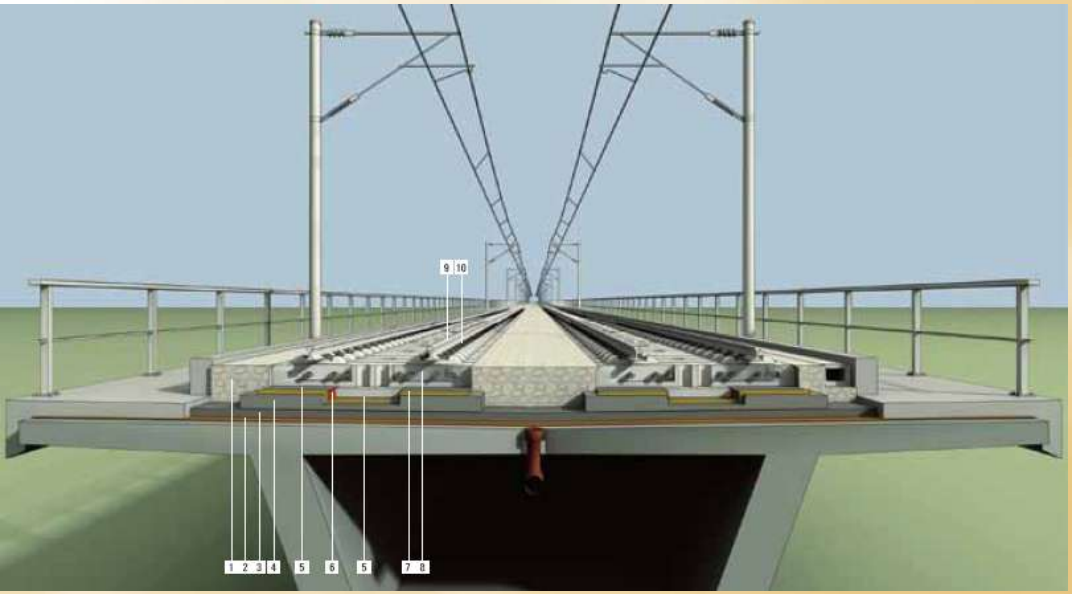
Tamping machine on the bridge.



Track on bridge

1. Methods of the track placing on the bridge

   E) ballastless track





Max Bögl system is shown in the pictures but other systems are also applied.

Track on bridge

2. The track in profile – standard requirements

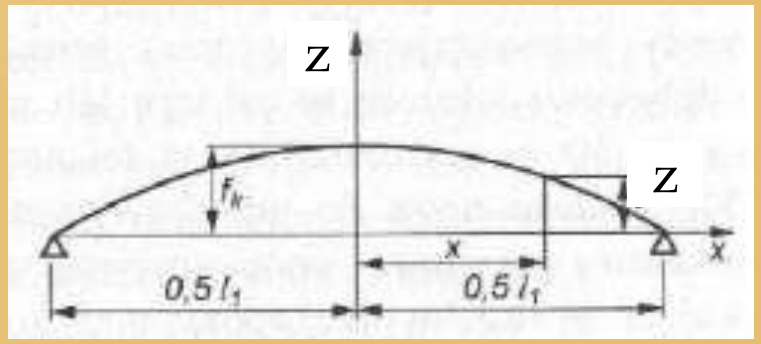
Track on a bridge longer than 30 m should be rectified to the technological elevation introduced during the span construction (calculated taking into account the deflection caused by the dead load and a half of the movable loads).

$$z = f_k \cdot \left[1 - 4 \left(\frac{x}{l_l} \right)^2 \right]$$

z- ordinate value measured from the level of the support for the abscissa x measured from the middle of the span

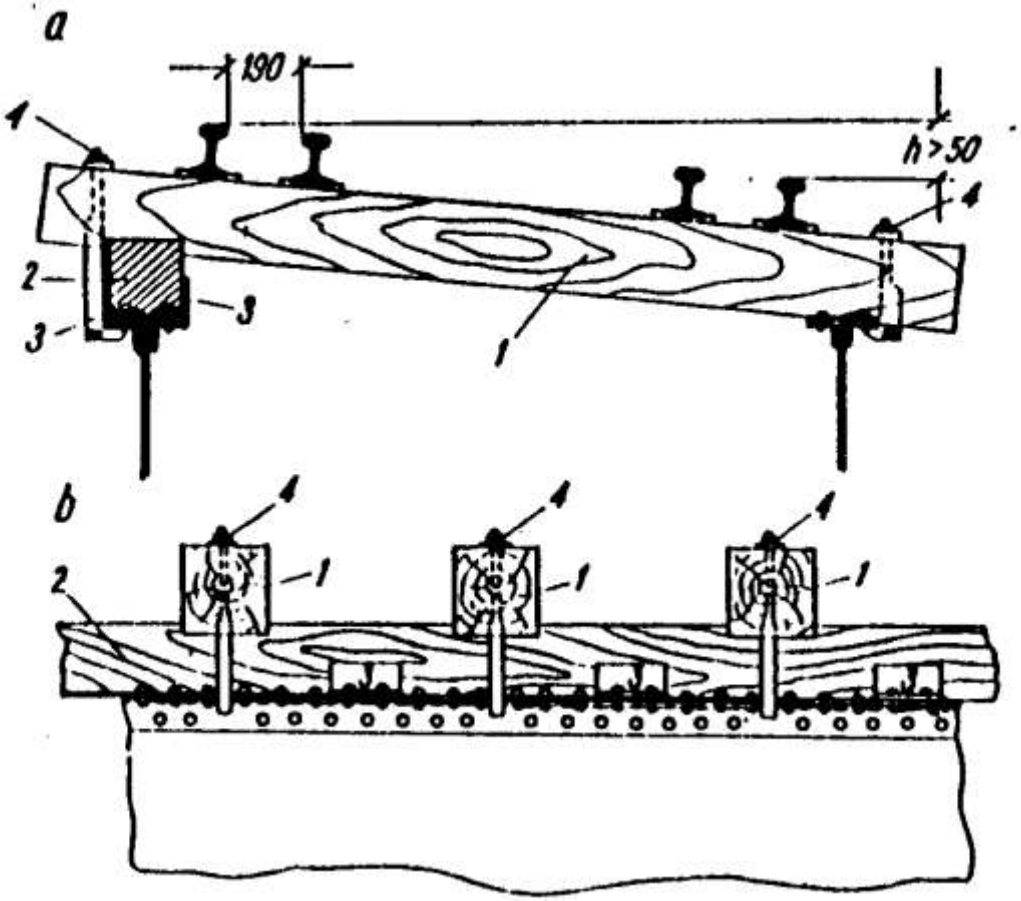
f_k- maximum z in the middle of the span

l_l- theoretical length of the span



Track on bridge

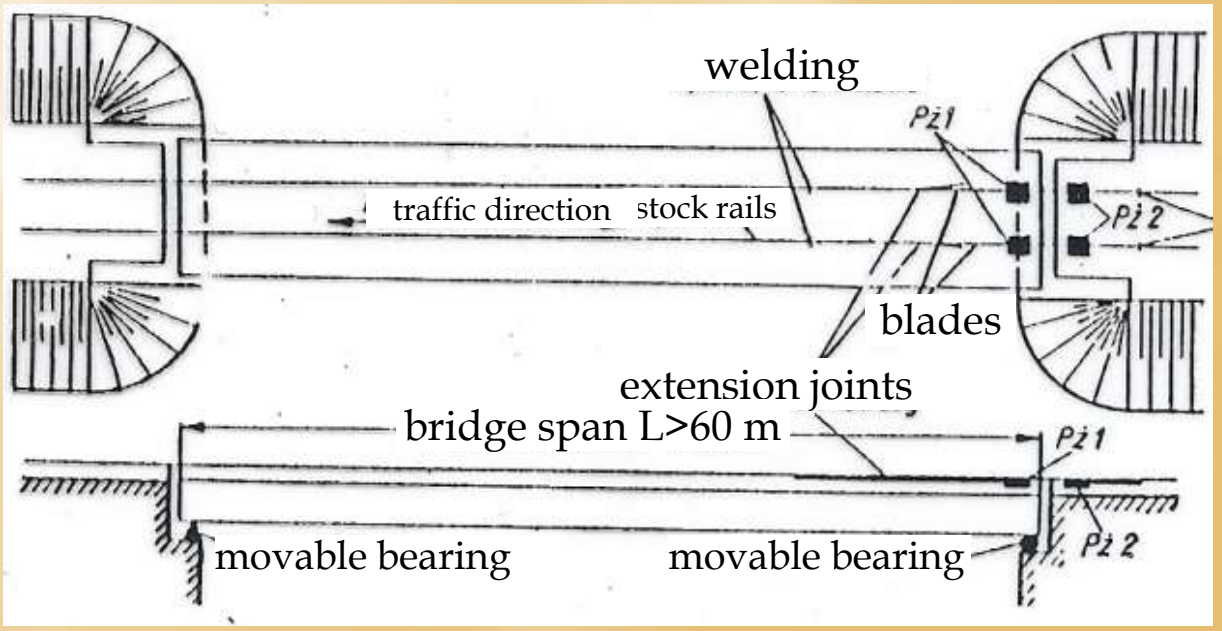
3. The track in cross-section - requirements



In case of the track in curve the cant is applied by means of rotation of sleepers and wooden pads to fit the pavement to the deck elements. This solution can be met in existing bridges.

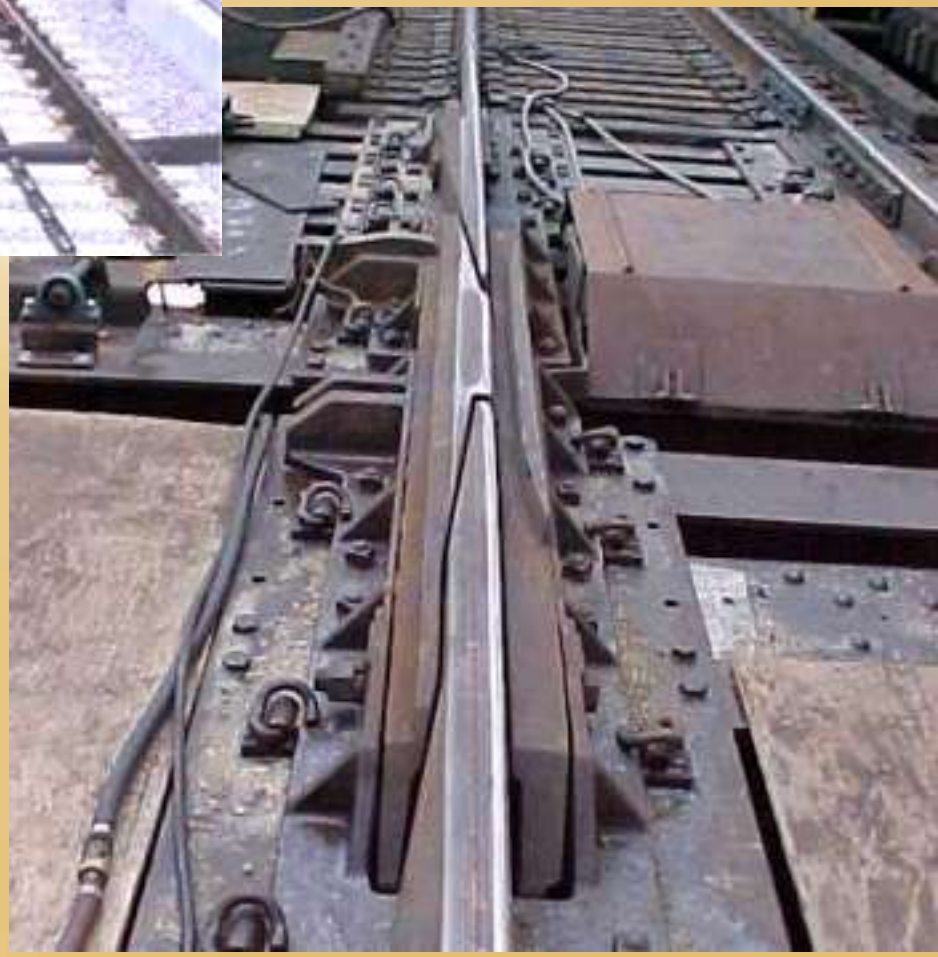
Track on bridge

4. Requirements related to the thermal elongation
   a) Use of long rails – they should be welded on the length of the bridge and the joints should be located at least 6 m from the ends.
   b) The track with sleepers should be fastened to the structure of a steel bridge of length L_o=20-60 m in the way enabling longitudinal movement of one structure with regard to another.
   c) On the steel structures longer than 60 m, over the movable bearing the dilatation devices on the track should be installed.



Track on bridge





Expansion joints on a bridge.

Remark:
On multitrack lines the expansion joints have to be placed in accordance to the normal traffic: trains should run in the direction from the blades to the stock rails.

Track on bridge

5. Safety requirements

For minimization of derailment effects on bridge along the running rails additional guiding rails should be placed (made of used rails, rolled shapes etc.) with the distance to the running rails in the range 190 - 210 mm. This applies to the track:

a) on bridges longer than 20 m,
b) on bridges of the length in the range 6-20 m located:
   - on curves with radius shorter than 350 m and on transition curves,
   - in places where effects of derailment could be especially dangerous: on stations, on embankments higher than 4 m, under viaducts and close to control towers.

Track on bridge





Derailment protection in Max Bögl system



