RAILWAYS

Special track

1. Slab track
2. Track on bridges
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 of 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
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.).
Application of the ballastless track:
1. On grade crossing
2. On stations (the track at the platforms)
3. In tunnels and bridges
4. Tramway track 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 maintenance (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
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).
REMARKS:
1. The track on the Akabane Station has been developed by Railway Technical Research Institute of Japan.
2. Longitudinal post-tensioned concrete 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.
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.
1. a) Chur, Switzerland and b) Drezno, Niemcy.
2. System Rheda City
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.
HBL - hydraulically-bonded layer – a layer of soil mixed with water and cement for increase its strength and time stability.
RHEDA (Classic)
RHEDA (Sengeberg)
RHEDA-Berlin HST - V1
RHEDA-Berlin HST - V2
RHEDA-Berlin HST - V3
RHEDA 2000

http://www.railone.com/
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 Green
The sleepers distance equals to 75 cm
So called Hungarian track

- Tramway lane
- Road lane

**Elastic mass**: rubber fastening strips, rubber tape (polyurethane or bitumin-caoutchouc)

**Precast concrete slab**: 18 cm
**Asphaltic concrete**: 12 cm
**Crushed stone**: 30 cm
**Sand subbase**: 10 cm

**Block rail**: 7 cm
**Rubber tape**: 1 cm
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.
Embedded Block System – with precast concrete box

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

http://www.sonneville.com/

The finished track
1. frost-protection layer
2. hydraulically bonded layer, $d=30$ cm
3. levelling course (mortar)
4. concrete slab, prestressed or reinforced by steel fibre
   $(6.50 \times 2.25 \times 0.20$ 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
9. connectors for joining the following slab
10. dilatation space

http://www.max-boegl.de
Track axis

Passable slabs for the Bögl system

FF Bögl slab track

Grouting mass

±0.00
1. Building a classical ballasted 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.
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
1. Methods of the track placing on the bridge
   A) Direct fastening of the rails to the structure
1. Methods of the track placing on the bridge

B) Rails on sleepers supported on the main girders
1. Methods of the track placing on the bridge

C) Rails on sleepers supported on the stringers (longitudinal deck elements)
1. Methods of the track placing on the bridge
   D) Rails and sleepers with ballast layer on the deck 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.
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.
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).

\[ z = f_k \cdot \left[ 1 - 4 \left( \frac{x}{l_1} \right)^2 \right] \]

- \( z \) - 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
- \( l_1 \) - theoretical length of the span
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.
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.
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.
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.
Derailment protection in Max Bögl system