International Design Practices, Applications, and Performances of Asphalt/Bituminous Railway Trackbeds

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Classic All-Granular Trackbed

Typical Thickness (mm)

- Ballast: 250-300
- Subballast: 100-150
Asphalt Underlayment trackbed without granular subballast layers

Typical Thickness (mm)
300
150

Asphalt Combination trackbed containing both asphalt and subballast layers

Typical Thickness (mm)
300
150
100

Ballastless trackbed containing thickened asphalt and subballast layers

Typical Thickness (mm)
300
150
United States Applications

Since 1981

• **Short Maintenance**—Road Crossings, Turnouts, Rail Crossings, Tunnels, Bridge Approaches, WILDS, etc.

• **Capacity Improvement**—Double Tracking, Line Changes, etc.
Trackbed Measurements & Evaluations

Earth Pressure Cell
Piezoelectric Film Sensor
Track Deflection
Track Stiffness
Long-Term Track Settlement
Pressure Cell

- Geokon Model 3500-2
- 9 in. Diameter
- Strain Gage
- Snap-Master
- Thermistor

Cell Placement on Asphalt
Empty Coal Train at Conway
Reduction of Dynamic Stresses

![Graph showing the reduction of dynamic stresses over time for 8 in. HMA surface and subgrade surface.](image-url)
• Matrix-based array of force sensitive cells
• Silver conductive electrodes
• Pressure sensitive ink – Conductivity varies
• Crossing of ink – strain gauge
This represents a typical pressure distribution between a machined steel tie plate and the rail with an included rubber bladder.
Positioning of Lead Wheel with Respect to Sensor

Lead Wheel Position

Average Pressure (psi)

0 100 200 300 400 500 600 700

10 Ties Before Sensor
8 Ties Before Sensor
6 Ties Before Sensor
4 Ties Before Sensor
2 Ties Before Sensor
Directly Above Sensor
2 Ties Past Sensor
4 Ties Past Sensor
6 Ties Past Sensor
8 Ties Past Sensor
10 Ties Past Sensor

Lead Wheel Over Sensor

F = 25372 lbf, P = 529 psi

Snapshot of the Lead Wheel Directly above the Sensor
Core Drilling
Subgrade Findings/Discussion

- In-situ Moisture Contents
  - Remain Consistent Over Time
  - Compare Favorably With Optimum
- Assume Unsoaked, Optimum Condition
- Bearing Capacity Remains At or Near Optimum
- Wide Range of Subgrades Evaluated
- Minimum Loading Induced Stress on Subgrade.
Asphalt Findings/Discussions

- Resilient Modulus Values are Intermediate in Magnitude—Typical of Unweathered Asphalt Mixes
- Asphalt Binders do not Exhibit Excessive Hardening (brittleness), Weathering, Deterioration or Cracking
- Asphalt is Insulated from Environmental Extremes
- Asphalt Experiences Minimal Loading Induced Stress
- Conditions Influencing Typical Failure Modes Experienced by Asphalt Highway Pavements don’t Exist in Asphalt Railroads Trackbeds.
International Applications

Italy

France

Germany

Japan

Spain

Austria
Italy

- Debated between cement and asphalt
- Asphalt – designated on all future high-speed passenger lines
Typical Cross Section

- 12 cm of asphalt with 200 MPa modulus
- 30 cm of super compacted subgrade with 80 MPa modulus
- 35 cm of ballast on top
“Supercompattato”  Bituminous sub-ballast
• Increased safety and structural reliability due to increased modulus and uniformity
• Reduced life-cycle cost on the infrastructure from reduced subgrade fatigue
• Increased homogenization of the track bearing capacity on the longitudinal profile and better ballast confinement
• Reduced ballast fouling due to improved drainage
• Reduced vibration levels throughout the track therefore reducing noise
• Reduced thickness compared to a conventional granular design

Policicchii, 2008
Japan

- Widely Used
- High Speed/Regular
- Firm Support for Ballast
- Reduce Load Level on Subgrade
- Facilitate Drainage

Momoya and Sekine, 2007
• **Performance Rank I:** Concrete roadbed or asphalt roadbed for ballastless track
  – Concrete base thickness = 190 mm
  – Asphalt base thickness = 150 mm
  – Stone base thickness = 150 mm

• **Performance Rank II:** Asphalt roadbed for ballasted track
  – Ballast thickness = 250-300 mm
  – Asphalt base thickness = 50 mm
  – Stone base thickness = 150-600 mm

• **Performance Rank III:** Crushed stone roadbed for ballasted track
• Paris to Strasbourg high-speed line
• 3 km asphalt subballast
• 574 km/hr (357mph) (test)
Comparative Cross-Sectional Profiles

Traditional and Asphalt Cross Sections (Bitume Info, 2005)
Asphalt Placement and Compaction (Faure, 2005)
Testing

• Conduct tests for 4 years (2007-2011)
• Temperature sensors continuously recording air temperature
• Pressure Sensors and Strain Gages checked twice a year
• Accelerometers
Spain

- Madrid – Valladolid
- Barcelona – French Border
Bituminous subballast sections built on the high-speed line Madrid-Valladolid, section between Segovia and Valdestillas (left) and on the high-speed line Barcelona-French Border, section Sils-Riudellots (right). Source: Teixeira (2009).
Track design with bituminous sub-ballast for Spanish high-speed lines standards. Source: Teixeira et al. (2009)
Germany

- Utilize several alternatives to conventional ballast design
- German Getrac A1/A3 – ballastless slab consisting of asphalt
- Concrete ties are anchored to the asphalt
Finished Getrac A3 Track at Brandleite Tunnel
Reasons for Implementing Asphalt Layers

How to install an Asphalt Layer?

Targets of an Asphalt Layer

– to allow road vehicles running on the sub-layer during construction phase independently from weather and sub-soil situation

– clear separation of sub- and superstructure during the whole service life

Advantages

– drainage effect for raining water hindering it penetrating the substructure

– avoiding the pumping up of fines into the ballast

– delivering a certain amount of elasticity

– homogenising the stresses affecting the substructure
Implementation

Consequently asphalt layers of 8 cm to 12 cm form a standard element for new high capacity and high speed lines in Austria.

Due to the long interruption of operation installing of asphalt layers are not proposed within track re-investment and maintenance operations.

picture a to c: new Koralm link, picture d: Schoberpass-line, built in 1991
Closure

• Current Practices

• Not All-Encompassing

• Typical Activities