Degradation and Rehabilitation of Ballast

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Agenda

• Load transfer function of the track
• Influence of ballast quality on track geometry
• Causes of ballast degradation and fouling
• Effective ballast cleaning
• Conclusion
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Longitudinal Load Distribution

- **No deflection** (hard and caked ballast)
- **High spot force**
- **High dynamic forces on ballast**
- **Low tension in railbase**

- **High deflection** (soft and wet ballast)
- **Low spot force**
- **Low dynamic forces on ballast**
- **High tension in rail base**

Track Modulus, rail deflection and rail base tension

\[ C_b = \frac{P}{y} [N / mm^2] \]

- \( C_b < 0.05 \)  ➞ Very weak
- \( C_b \geq 0.05 \)  ➞ weak
- \( C_b \geq 0.10 \)  ➞ good
- \( C_b \geq 0.15 \ldots 0.30 \)  ➞ Very good
- \( C_b \geq 0.30 \ldots 0.50 \)  ➞ Concrete base
Vertical Load Distribution

\[ \sigma_2 < \sigma_{\text{sub}} \text{ - good ballast} \]

Vertical Load Distribution

\[ \sigma_2 > \sigma_{\text{sub}} \text{ - fouled ballast} \]
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Ballast and Subgrade Analysis by GPR
(Austrian Railways)
Ballast/subgrade and Track Geometry

TQI

Detoriation rate
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Definition of Ballast Fouling

• Proportion of fines – expressed as a weight percentage of the total sample
• New ballast
  • 3 to 5% smaller than 22.4 mm
• Fouled ballast
  • UIC criteria: more than 30%- 40% of fines
  • Fuller criteria: closest possible position of the grains to each other is reached, the ballast has become completely impermeable
Causes of Ballast Fouling

• Attrition
  • Main cause traffic load
    • Rate of development of fines – about 3.6 – 5.2 kg per million ton of traffic
    • Influence of tamping negligible
      • Only 1.8 – 3.9 kg per tamp and tie
      • After every 50 million gross tons, the fines due to traffic are 260 kg, tamping only 3.9 kg (maximum)

Causes of Ballast Fouling (continued)

• Contamination from outside by air (wind)
• Spillage
• Penetration of subsoil from underneath
  • Ballast layer of insufficient thickness
  • Water traps and pumping effect
  • Vicious circle if soft spots are not maintained in time
Examples of Ballast Fouling

- Attrition under ties

Examples of Ballast Fouling

- Percentages of fines at different levels

English

- Attrition under ties

English

- Percentages of fines at different levels

English
Examples of Ballast Fouling

• Turnout
  • Attrition under ties of main track
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Criteria for Rehabilitation of Ballast Bed

- Rapid deterioration of track quality and necessity of frequent surfacing
- Further information from track recording car
  - Considerable deviations in
    - Longitudinal level
    - Twist measured over a 5 m basis
    - Plasser & Theurer ADA II: ballast cleaning quality coefficients
- Visual inspections and sampling of the ballast bed
  - More than 30% of fines - ballast cleaning becomes appropriate
  - More than 40% - ballast cleaning is inevitable
Criteria for Rehabilitation of Ballast Bed
Effective Ballast Cleaning

• Fouled shoulder

Shoulder Cleaning

Cutting full width of shoulder
Shoulder Cleaning

Full shoulder cut with desired inclination

Unsufficient cutting range
Full Section Undercutting - cleaning

- Fouled ballast under ties
  - Only exchange or deep screening is sustainable
  - Constantly lifting and re-ballasting of tracks does rather cause additional problems

Example of Deferred Undercutting

Loose ballast in crib
Important Features of Undercutter - Cleaners

Undercutting Device

• Must facilitate the production of a straight cut subgrade
  • Longitudinal direction
  • Cross direction with the prescribed cross-fall of approx. 4 – 5% (1: 25 to 1: 20).
    • According to expert opinions, this is best achieved by combining an excavating chain with a cutter bar. The ballast must be excavated over the entire width of the ballast bed. It is therefore necessary to provide an extension of the cutter bar, if required (fig. 11).
  • Deep undercutting as fines in the ballast usually build up from the bottom to the top
High Capacity Screening Units

← Double
and
↓ Triple shaker boxes
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Improvement of track geometry experience - Austria

Change in the longitudinal level after subgrade rehabilitation (Line 4014, Track 2, Km 254,000 – 258,500)

Track geometry quality as a standard deviation of the longitudinal level

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