PRESSURE MEASUREMENTS AND STRUCTURAL PERFORMANCE OF HOT MIXED ASPHALT RAILWAY TRACKBEDS

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1.0 Introduction

- In 2005, 1.7 trillion ton-miles of freight was carried over the nation's nearly 227,000 km railroad network
- The average freight car weight has increased to 117 metric tons with most new cars having gross weights of 130 metric tons
- Developing and specifying premium track structures and components to adequately carry the increased tonnage is a current reality of the industry

1.0 Introduction (cont)

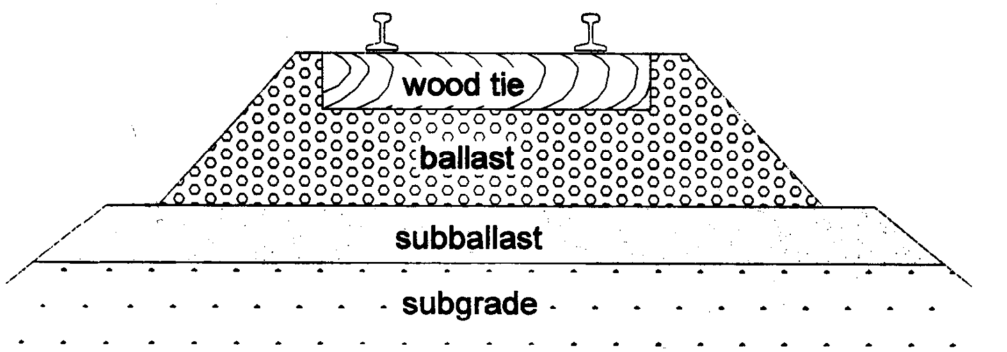
- Advanced technologies are necessary to provide stronger and longer-lasting track and support structures to accommodate the record volumes

- Trackbeds that incorporate a layer of hot mixed asphalt (HMA) in lieu of the subballast are becoming more prevalent and have been shown to have numerous advantages over traditional all-granular (ballast) trackbeds

2.0 Prevailing Design Practices

- Typical trackbed cross sections

(a)



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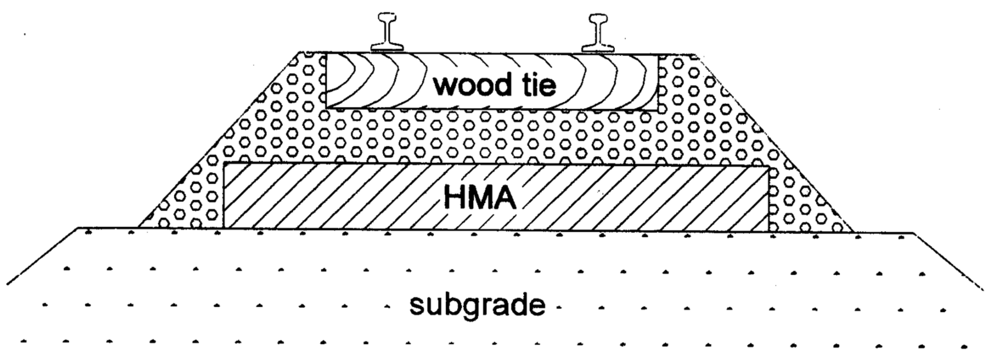


- Typical All-Granular Ballast Trackbed
  - Ballast = 250 to 300mm
  - Subballast = 150 mm
- Typical HMA Trackbed
  - Ballast = 150 to 200mm
  - HMA = 150 mm

2.1 Design Specifications

- Asphalt underlayment design and construction standards for railways typically follow recommendations set forth by the Asphalt Institute
- Prevailing dense-graded highway base mix in the area having a maximum aggregate size of 25 to 37.5 mm
- Asphalt binder content is increased by 0.5% above that considered optimum for highway applications. Yields a low to medium modulus (plastic) mix with a design air voids of 1 to 3%.
- Mat densified to less than 5% in-place air voids

2.2 Installation Equipment and Costs

- For short maintenance/rehabilitation projects:
  - HMA back-dumped on grade and spread with a trackhoe or small dozier and compacted with a conventional vibratory roller
  - Cost to place HMA insignificant relative to total track removal and replacement costs
- For new construction with a prepared subgrade:
  - HMA placed with conventional asphalt laydown (paving) equipment and compacted with large vibratory rollers
  - Cost to place HMA is equal to or less than costs to place granular subbalast

3.0 Observed Performance of Asphalt Underlayment

- Rose and Lees (2008) reported on investigations conducted on numerous in-service HMA trackbeds on CSXT and BNSF revenue lines in several states
- HMA trackbeds ranged from 12 to 26 years of service and included varying geographical and geological conditions
- Investigations involved a variety of subgrades ranging from low-strength, high plasticity (fat) clays to moisture-sensitive silts to higher quality granular materials.

3.1 Asphalt Underlayment Durability

- HMA mixes did not exhibit any indication of excessive hardening (brittleness), weathering, or deterioration
- Insulative effects of the overlying ballast
  - Protects HMA from sunlight and excessive temperature extremes
  - Mat remains slightly flexible → No indication that the HMA mats are experiencing any loss of fatigue life.

3.2 Effects on Structural Performance

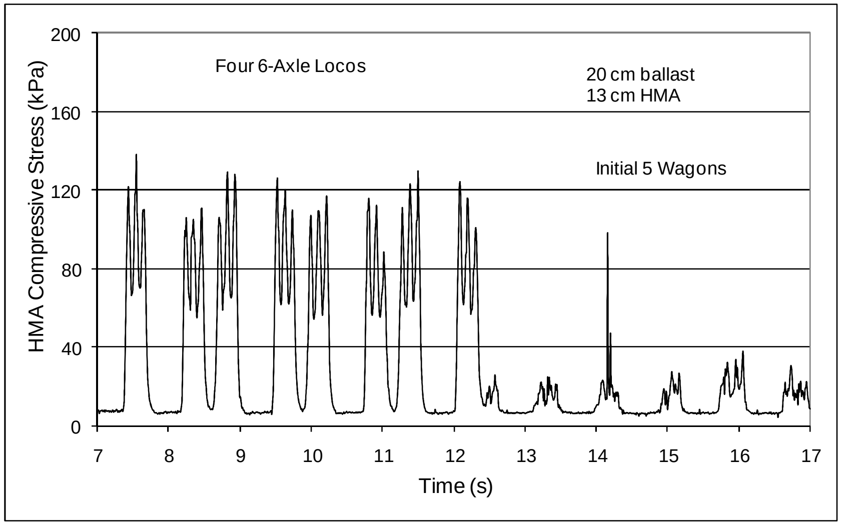
- Angular ballast particles slightly penetrate or imbed into the top surface of the asphalt mat
  - Increases interfacial shear strength
  - Improves overall structural value of the track structure
- High level of support provided by the HMA mat maintains a high degree of ballast compaction
  - Increased modulus, reduced wear, and increased ballast life
- Excellent long-term track geometry indicators

3.3 Trackbed Pressure Measurements

- Two heavy-tonnage sites were selected for the trackbed pressure tests:
  - A CSXT revenue mainline in east-central Kentucky, near Conway, KY
  - The test trackbed at TTCI in Pueblo, Colorado.
- Trackbed pressure measurements were obtained at prevailing speeds
- Pressure measurements were recorded using hydraulic type earth pressure cells, imbedded above and below the HMA mat

3.3.1 CSXT Revenue Line Tests

(a)



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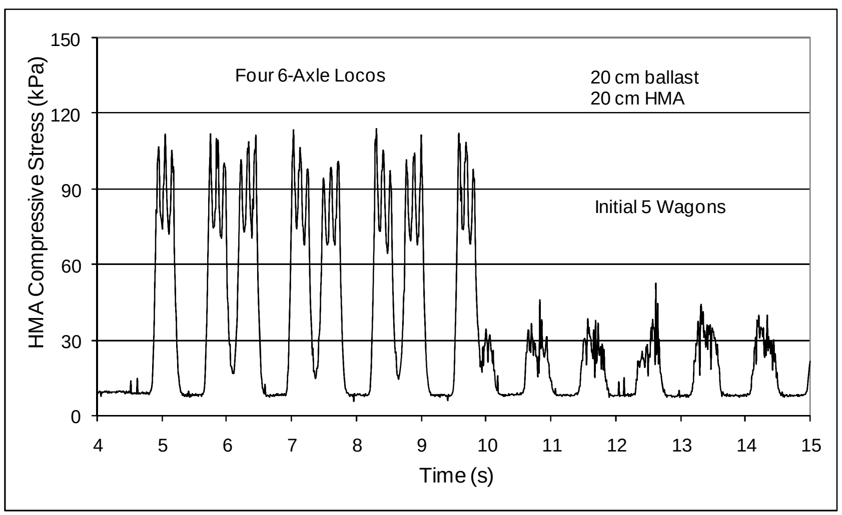
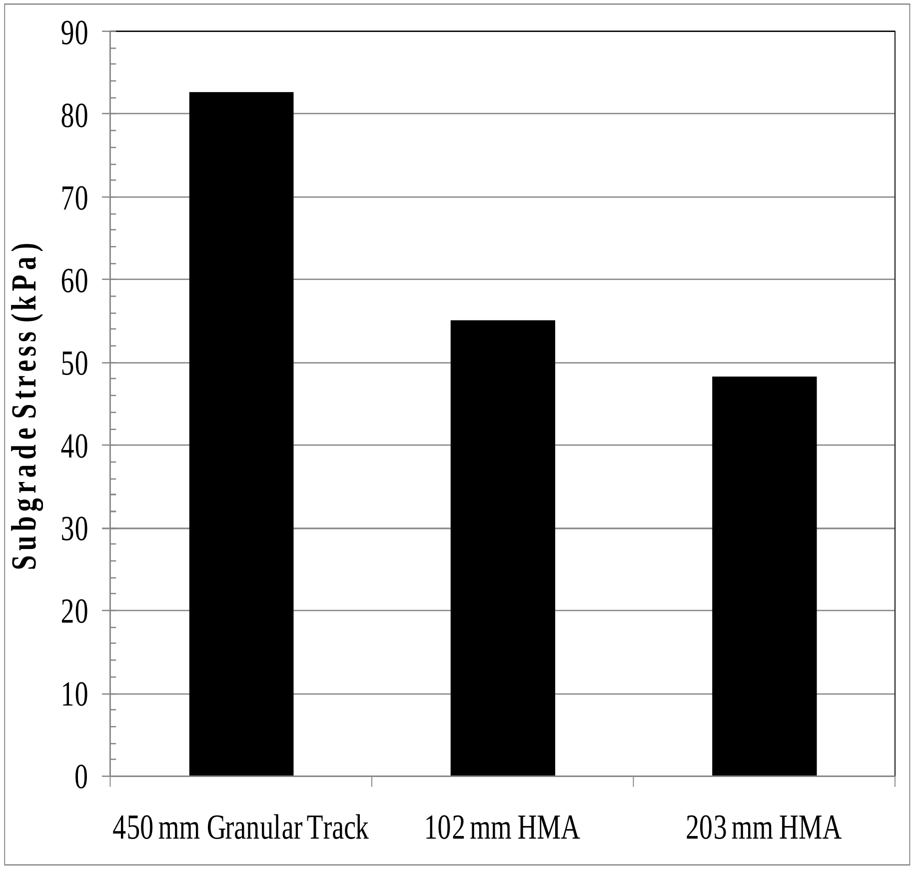


- 130-metric ton locomotives. Average wheel load = 16 metric tons
- 29 metric ton empty cars. Average wheel load = 3.5 metric tons.

- By comparison, typical tire pressures imposed on highway asphalt surfaces under loaded trucks range from 700 kPa to over 1,050 kPa

3.3.2 TTCI High Tonnage Trackbed

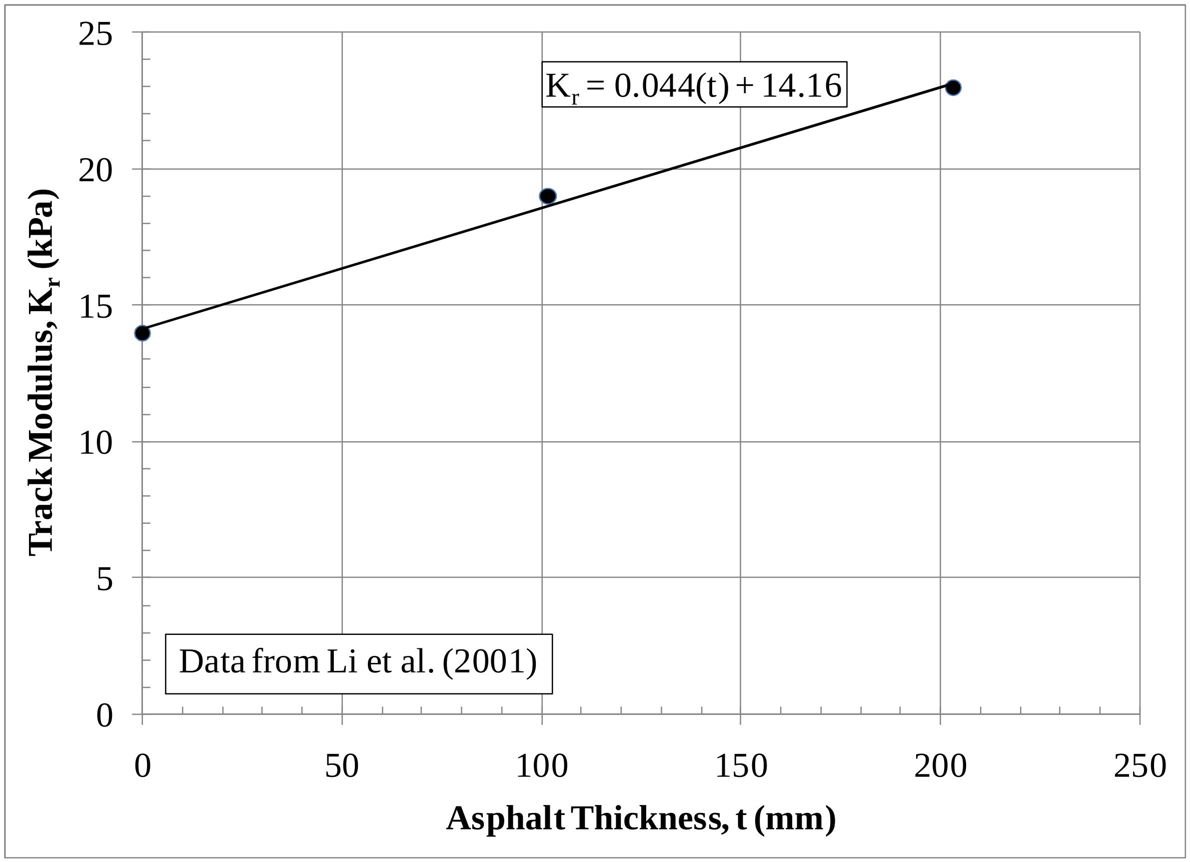


- 36-metric ton axle loads (Average wheel load = 18 metric tons)

<u>Subgrade Soils:</u>

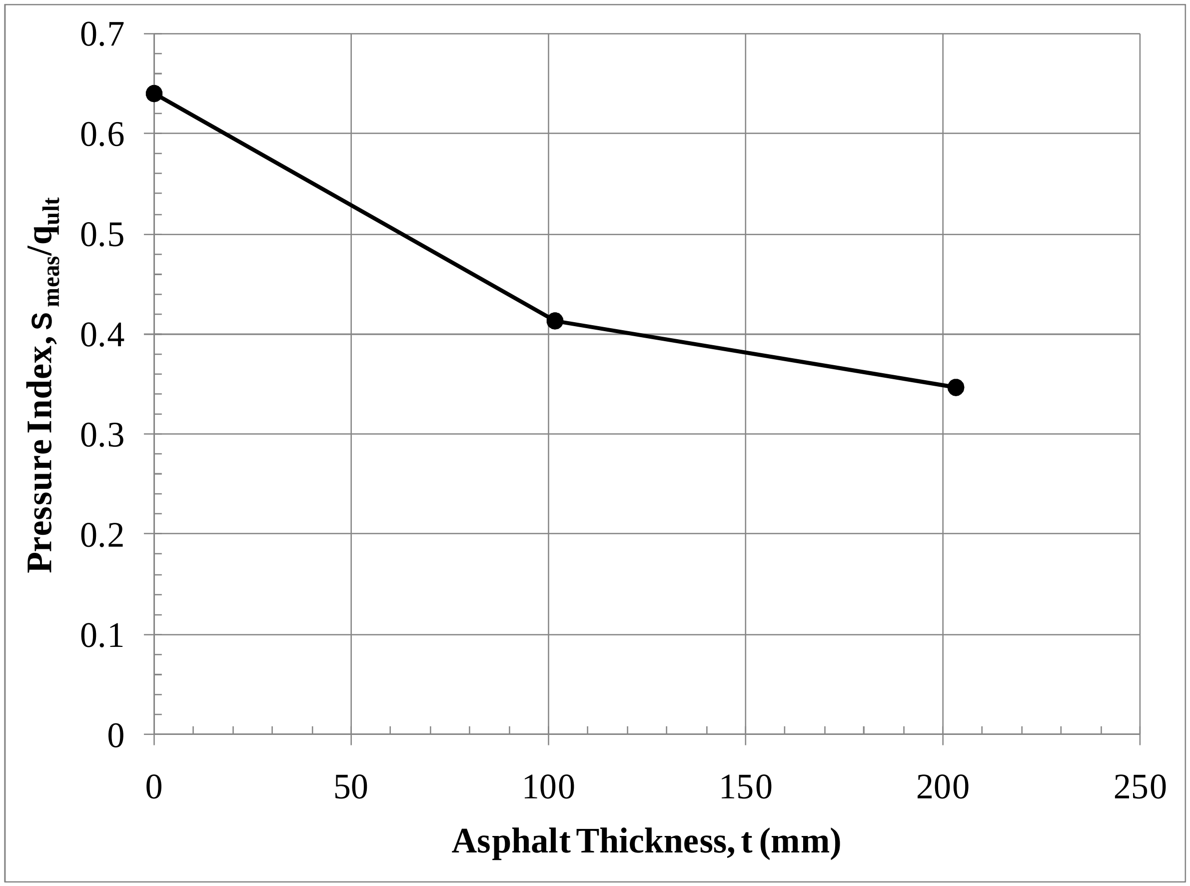
- Vicksburg (Buckshot) clay
- LL = 64
- PI = 38
- w_n = 34.6%.
- S_u = 90 kPa

3.4 Trackbed Structural Performance



- Increased track modulus = decrease in track settlement = more durable tracks

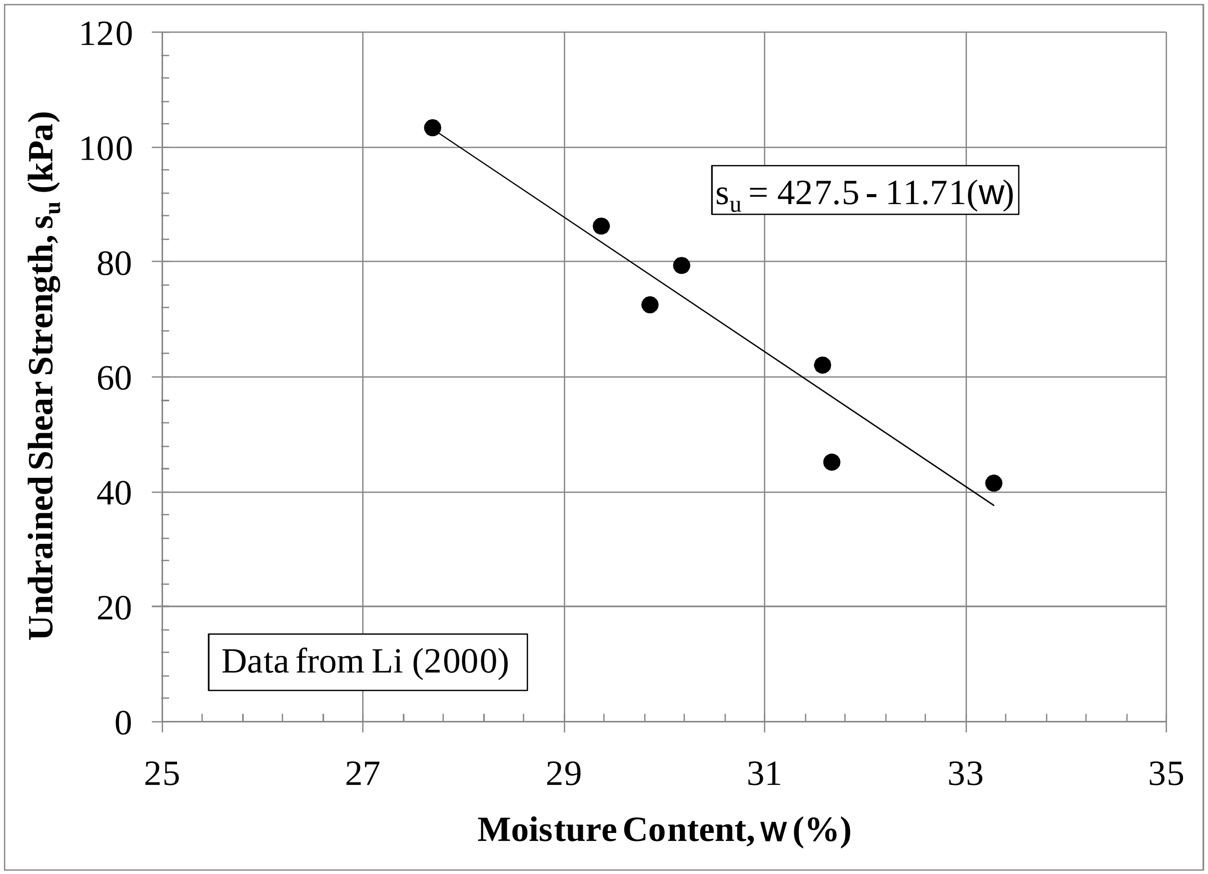
3.4 Trackbed Structural Performance (cont)



- Pressure Index = ratio of pressure at the layer interface, to the predicted bearing capacity of the layer
- A pressure index value of unity implies failure of the layer

3.5 Benefit to the Subgrade

- In-situ moisture contents were within 1% of the laboratory determined optimum values for maximum density.



- Maintaining moisture content at optimum, as opposed to increasing moisture content = maintain shear strength

4.0 Conclusions

- The overlying ballast acts as an insulator to the asphalt layer, protecting the HMA from sunlight and excessive temperature extremes. Thus, greatly increasings the fatigue life of the HMA layer.
- The combined supports provided by the HMA mat and the confined ballasts layer are believed to be primary contributors to maintaining long-term track geometry.
- The arching effects of HMA layer significantly reduces the level of stress transmitted to the subgrade soils.

4.0 Conclusions (cont)

- The track modulus tends to increase with increasing asphalt thickness. The increase in track modulus implies a decrease in track settlement, which translates into more durable tracks.
- The asphalt underlayment significantly improves the pressure index. The factor of safety against punching shear failure increases by roughly 35 percent with 102 mm of HMA underlayment and by approximately 46 percent for 203 mm of HMA underlayment.
- The in-situ moisture contents were within one percent of the laboratory determined optimum values for maximum density. This implies that the strengths and load carrying capacities of the underlying materials remained uniformly high.

Questions

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