Integrated Road Research Facility in Edmonton

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Outline

➢ Background

➢ Overview of the IRRF
  ▪ TDA Embankment Sections
  ▪ Pavement Performance Sections
  ▪ Insulation sections

➢ 3 Years Field Performance Results
Introduction or background

Everything started from discarded tires
Number of scrap tires generated per year

- **Alberta**: 5.3 Million
- **U.S.**: 313 Million
- **Europe**: 250 Million
- **Canada**: 33 Million
Discarded tires

- Ugly to the environment;
- Costly to put in landfills;
- Unregulated stockpiles: fire and health hazardous.
Tire Derived Aggregate (TDA) has been used in various civil engineering applications: fill embankment for roadways & retaining walls and also as insulation layers.
Engineering Properties of TDA

• Light weight (1/3 to 1/2 conventional soil fill material)
• Free draining (Permeability greater than 10 cm/s)
• Low earth pressure (up to 50% lower)
• Good thermal insulation (8 times better than gravel)
• Durable
Material Type

PLTT particles
• Thin & plate-like

OTR particles
• Thick & irregular
IRRF test road

Edmonton Waste Management Center (EWMC)

EWMC Access Road
Flexible pavement performance in a cold climate:

- Evaluate use of pavement insulation layers;
- Study the performance of pavement structure under different traffic and environmental loads.
  - Effect of deep frost & freeze-thaw cycles on pavement structural response
Integrated Road Research Facility (IRRF)

Smart Road
- Recycled Materials for Highways
- Pavement Performance in Cold Regions
- Insulation Layers for Highways

Laboratory
- Asphalt and Soil Material Characterization
- Waste Material Characterization
- Cold Room
IRRF test road overview

- **University**
- **High-speed datalogger**
- **Control section**
  - **Bottom ash - 1 m**
  - **Polystyrene - 10 cm**
  - **Polystyrene - 5 cm**
- **Pavement monitoring**
- **Control section**
  - **Weigh-in-motion**
- **Pavement monitoring**
  - **Insulated sections**
  - **Polystyrene - 10 cm**
  - **Polystyrene - 5 cm**
  - **Control section**
- **Control section**
  - **Tire-soil mix**
  - **Off-the-road tires**
  - **Light truck tires**
- **TDA embankment**
Remote data collection system

- Antenna installed on the on-site trailer
- Automatic Data collection
- Remote desktop access
- Computer in on-site trailer
- Computer at UofA
IRRF test road overview

- University
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- TDA embankment

Images of different sections and materials used in the test road:
- Bottom ash
- Polystyrene
- Control section
- Weigh-in-motion

Note: The images show a section of the test road with various materials and equipment installed for monitoring and testing purposes.
Embankment layers from top to bottom

1. Compacted soil cap (1 m)
2. TDA layer (3 m)
3. Intermediate separator soil layer (0.5 m)
4. TDA layer (3 m)
25 settlement plates in each section
Settlement, bottom layers

Embarkment construction

Post-stage 1 paving

Post-stage 2 paving

Settlement (cm)

6-20-2012
9-20-2012
12-20-2012
6-20-2013
9-20-2013
12-20-2013
6-20-2014
9-20-2014
12-20-2014
6-20-2015
9-20-2015
12-20-2015
6-20-2016
9-20-2016
12-20-2016
6-20-2017
9-20-2017
12-20-2017

Bottom (SP2)
- PLTT
- OTR
- PLTT-soil
Settlement, top layers

Embankment construction

Post-stage 1 paving

Post-stage 2 paving

 Settlement (cm)

Top (SP6)
- PLTT
- OTR
- PLTT-soil

Post-stage 1 paving

Post-stage 2 paving
Temperature, bottom layers

Temperature (°C)

Date


-40 -30 -20 -10 0 10 20 30 40

Bottom (T2)
- PLTT
- OTR
- PLTT-soil
- Ambient Air
Temperature, top layers

-40 -30 -20 -10 0 10 20 30 40


Top (T5)
- PLTT
- OTR(broken)
- PLTT-soil
- Ambient Air
IRRF test road overview

**Key Components:**
- University
- High-speed datalogger
- Insulated sections
- Pavement monitoring
- Control section
- TDA embankment
- Off-the-road tires
- Light truck tires
- Tire-soil mix
- Weigh-in-motion

**Materials:**
- Bottom ash
- Polystyrene

**Features:**
- Insulated sections
- Pavement monitoring
Control sections

Instrumentation Layout

Section 1

Section 2

250 mm HMA

450 mm granular

Silty clay subgrade
Sensors installation
Controlled Traffic Tests

Horizontal strain (microstrain)

Vertical strain (microstrain)

Time (m sec)
Controlled traffic tests

Measured strain pulses at the bottom of the HMA
Live passing traffic (2000 trucks per day)

FHWA Class #5

FHWA Class #6

Stress Pulse Shape
Seasonal monitoring of thermal strains

- Max: 789 µm/m (July)
- Average (Fall): 50 µm/m
- Average (Winter): 92 µm/m
- Average (Spring): 170 µm/m
- Average (Summer): 459 µm/m
- εl did not return to its initial value
IRRF test road overview

University

High-speed datalogger

Control section

Insulated sections

Pavement monitoring

Control section

Tire-soil mix

Off-the-road tires

Light truck tires

TDA embankment
Insulated sections
Construction process
Alberta generates 68 percent of its electricity from coal, which generates a lot of ashes. Thus, the productive use of bottom ash is an important environmental consideration in managing waste materials in Alberta.
Temperature change across the depth

- Control Section 2017-2018
- Bottom Ash 2017-2018
- Polystyrene 2017-2018

Temperature (°C)

Depth, m
Moisture and Temperature
1.7 m below surface
Volumetric Water Content Variations
(Control Section on Top of Subgrade)
Freeze and thaw depth
Thermal and Moisture profile Simulation
• Overall mean air temperature was 6.48 °C
• Overall mean HMA temperature was 10.38 °C
Seasonal FWD testing
Deflection at geophone 1 (micron)

Station 130+

Deflection

Lowest Deflection

Maximum Deflection

Highest Deflection

- 25 October-13 (T = 9 C)
- 05 September-14 (T = 16 C)
- 12 March-15 (T = 2 C)
- 25 May-15 (T = 29-36 C)
- 18 SEP15 (T = 14 C)
- 29 April-14 (T = 18 C)
- 17 October-14 (T = 7 C)
- 08 April-15 (T = 7 C)
- 5 June-15 (T = 26,29 C)
- 14thOCT15, T = 10-11
- 30 May-14 (T = 20 C)
- 18 November-14 (T = 1 C)
- 21 April-15 (T = 13-16 C)
- 09 Jul-15 (T = 48-49 C)
- 17 July-14 (T = 20 C)
- 10 December-14 (T = 0 C)
- 05 May-15 (T = 16,17 C)
- 18 AUG15 (T = 21-22 C)
## Resilient Modulus of Subgrade

<table>
<thead>
<tr>
<th>Season</th>
<th>Average Mr (MPa)</th>
<th>Mr Ratio</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Summer</td>
<td>Fall</td>
</tr>
<tr>
<td>CS</td>
<td>134.7</td>
<td>144.4</td>
</tr>
<tr>
<td>B.Ash</td>
<td>133.0</td>
<td>136.5</td>
</tr>
<tr>
<td>Poly-10</td>
<td>146.9</td>
<td>150.7</td>
</tr>
<tr>
<td>Poly-5</td>
<td>137.3</td>
<td>139.9</td>
</tr>
</tbody>
</table>
Laboratory Testing
Resilient and Dynamic Modulus Test
Laboratory characterization

Asphalt dynamic modulus

Resilient modulus of subgrade against $\sigma_d$ with different F/T cycles @ $\sigma_3 = 41.4$ kPa

Subgrade resilient modulus
Sample Production
Hamburg Wheel Tracker

AASHTO T324
Four-Point Beam Apparatus

- Sinusoidal loading
- Frequency range of 5 to 10 Hz

380mm L × 50mm T × 63mm W
HMA Specimen
Acknowledgment

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