Road and Drainage Projects Using Recycled Scrap Tires

RMA & Semi tire sidewall weight
EGLE Scrap Tire Grants and NextCycle Michigan

- EGLE Scrap Tire offers three types of grants:
  - **Cleanup** – granted first, currently no match component
    - Communities
    - Private Site Cleanups
    - *We are looking for Partners to host a cleanup trailer – can your Road Commission assist?*
  - **Law Enforcement** – to prohibit dumping of tires
    - Includes purchase of surveillance equipment for problem sites
  - **Market Development**
    - 50% Match
    - Utilize scrap tires in a project (roads) or create a product with scrap tires

- **NextCycle Michigan** - [www.nextcyclemichigan.com](http://www.nextcyclemichigan.com)
  - Goal – to increase recycling in Michigan
  - One of the six segments is the Roads Track
    - Applications closed for round 1 Roads Track in December, currently reviewing!
  - Public-Private partnership
2019 - Dickinson County Road Commission
County Road 607 Project

Partners: Dickinson CRC, MTU & EGLE

2019 IMPRESS Award
Excellence in Collaboration
is presented to the
Dickinson County Road Commission
Michigan Department of Environment, Great Lakes, and Energy
Michigan Technological University
for
Collaboration Makes a Better Road - CR 607 ECR Research Project
March 12, 2020
2019 Dickinson County Project Leads to 2021 Kent County Road Commission Cascade Road (Burton to 28th Street)

Partners:
- Kent County Road Commission
- Michigan Technological University
- Asphalt Plus (rubber supplier)
- Reith-Riley (paving contractor)

Right 3 lanes are dry process RMA
Left 2 lanes are conventional asphalt for comparison purposes
2018 Kalamazoo Project Leads to 2021 Project “100 Lane Miles of Chip Seal”
2021 Rubber Modified Chip Seal (RMCS) Project

Partners:
- County Road Commissions:
  - Antrim
  - Bay
  - Wexford
- Entech (rubber supplier)
- Cactus/Entech (paving contractor)

- 104 lane miles rubberized chip seal
- 290 Scrap Tires used per Lane Mile
- Total use: 422,240 pounds (211.12 T)
- Roads were PASER ratings 3 & 4
- PASER (Pavement Surface Evaluation and Rating) System uses a scale of 1 – 10, with 1 being worst condition
2017 Midland County Road Commission
Eastman Road TDA Installation
2017 Midland County Road Commission Leads to 2021 Ingham CRD “Road Lasagna”
Additional Options
Porous Pave, Septic & Rubber Mulch

Rubber Mulch
Buy once, install once

Porous Pave from Grant, Michigan
https://www.porouspaveinc.com/
Innovative Applications of TDA
Turning Discarded Tires into TDA Tire Derived Aggregate
ASTM 6270 B Material
Tire Derived Aggregate (TDA) is a lightweight material. The Specific Gravity* (SG) of TDA is 1.3. It is two times heavier than wood chips, similar to expanded shale, and half as much as gravel and soil:

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Material</th>
<th>Specific Gravity, (-)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EPS geofoam</td>
<td>0.01 - 0.04</td>
<td>ASTM D6817 - 13</td>
</tr>
<tr>
<td>2</td>
<td>Wood chips</td>
<td>0.50 - 0.56</td>
<td>Smith 1961</td>
</tr>
<tr>
<td>3</td>
<td>Expanded shale</td>
<td>1.2</td>
<td>Bundur et al. 2017</td>
</tr>
<tr>
<td>4</td>
<td>TDA</td>
<td>1.3</td>
<td>Meles et. al 2013; Mwai et al. 2016</td>
</tr>
<tr>
<td>5</td>
<td>Gravel (river bed)</td>
<td>2.6</td>
<td>Mwai et al. 2016</td>
</tr>
<tr>
<td>6</td>
<td>Soil</td>
<td>2.7</td>
<td>ASTM D854-92</td>
</tr>
</tbody>
</table>

*Specific Gravity is the ratio of the density of a substance to the density of reference material (in this case water).

**Conclusion:** TDA can replace traditional aggregates in civil engineering applications to reduce lateral load and earth pressure two-times on the soft soil, existing foundations, and walls.
TDA: DRY UNIT WEIGHT [EMPIRICAL]

A loosened TDA, during shipping and stockpiling, has a Dry Unit Weight (DWU) that is three times lower than sand and four-times lower than clay soil. It is also half of the expanded shale aggregate and similar to wood chips. A compacted TDA, during field application, has a dry unit weight that is comparable to fine expanded shale and soft wood chips. It is twice lower than sand and trice lower as a clay soil:

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Material</th>
<th>Dry unit weight, loosened, lb/yd³</th>
<th>Dry unit weight, compacted, lb/yd³</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EPS geofoam</td>
<td>35</td>
<td>35</td>
<td>Akay, 2016</td>
</tr>
<tr>
<td>2</td>
<td>TDA</td>
<td>675 - 945</td>
<td>1,215 - 1,350</td>
<td>CalRecycle, 2016</td>
</tr>
<tr>
<td>3</td>
<td>Wood chips</td>
<td>864 - 1080 c,1</td>
<td>1,215 - 1,836 d,2</td>
<td>Abu Eusuf &amp; Al Hasan 2012 ¹; Kocsis 2015 ²</td>
</tr>
<tr>
<td>4</td>
<td>Expanded shale</td>
<td>1,134 - 1296</td>
<td>1,323 - 1,674</td>
<td>Stoll et al. 1985</td>
</tr>
<tr>
<td>5</td>
<td>Sand, CA b</td>
<td>1,944 - 2,106</td>
<td>2,322 - 2,970</td>
<td>Lunne et al. 2019</td>
</tr>
<tr>
<td>6</td>
<td>Clay soil</td>
<td>2,781 - 2,862 l</td>
<td>3,348 - 3,537 ²</td>
<td>Romero et al., 1999 ¹; Blotz et al. 1998 ²</td>
</tr>
</tbody>
</table>

**Conclusion**: Shipped TDA and Applied TDA has different unit weights. During compaction, dry unit weight of TDA increases twice and volume that TDA occupies decreases twice.
Fig 2. Results for internal direct shear test of TDA: Normal stress (a), Shear stress (b), and secant friction angle (c) (Fox et al. 2017)

TDA: INCREASED SHEAR STRENGTH

- According to Fox and colleagues (2017), TDA yields a peak shear strength of 52 kPa at a horizontal displacement of 460 mm. For initial normal stress of 77kPa, the peak value of secant friction angle is 30.2° at 403 mm displacement. Since TDA is placed under 5-20 feet below the surface, as the loading gets larger, the internal strength increases due to mechanical interlocking effect (Balunaini et al. 2009).
The shear strength of a soil aggregate is primarily derived from friction between the particles, occlusion and interlocking (Lambe et al. 1991; Wang et al. 2019). TDA also possess interlocking property which increases its shear strength during compaction and compression.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Material</th>
<th>Interlocking</th>
<th>Source</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TDA ASTM 6270</td>
<td>Yes</td>
<td>Larger pieces and protruding wires</td>
<td>Balunaini et al. 2009</td>
</tr>
<tr>
<td>2</td>
<td>Gravel</td>
<td>Yes</td>
<td>Movement of gravel particles into voids leads to local contraction and particle interlocking during shearing.</td>
<td>Li et al. 2013</td>
</tr>
<tr>
<td>3</td>
<td>Soil</td>
<td>Yes</td>
<td>Interlocking and occlusion contact</td>
<td>Wang et al. 2019</td>
</tr>
<tr>
<td>4</td>
<td>Expanded shale</td>
<td>No</td>
<td>Irregular shape and less smooth surface of crushed expanded shale increases interlocking between cement paste and aggregates</td>
<td>Liao et al. 2019</td>
</tr>
<tr>
<td>5</td>
<td>EPS Geofoam</td>
<td>No</td>
<td>-</td>
<td>EPS Industry Alliance 2012</td>
</tr>
</tbody>
</table>

**Conclusion:** TDA has the highest mechanical interlocking property among other traditional and lightweight aggregates due to larger parts and protruding wires that increase its shear strength.
PERMEABILITY PROPERTY

- TDA is an excellent drainage material due to high porosity and low water absorption. Its permeability is similar to very coarse gravel. It surpasses fine gravel 10 times, wood chips 100 times, coarse sand 3,000 times and fine sand more than 30,000 times.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Material</th>
<th>Hydraulic conductivity, m/s</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TDA ASTM 6270</td>
<td>0.3 - 0.51</td>
<td>Mwai et al. 2016</td>
</tr>
<tr>
<td>2</td>
<td>Clean Gravel</td>
<td>$10^{-2}$ - 1.0</td>
<td>Cabalar &amp; Akbulut 2016; Terzaghi &amp; Peck 1964</td>
</tr>
<tr>
<td>3</td>
<td>Expanded Shale</td>
<td>$4 \times 10^{-2}$ - 0.6</td>
<td>Bowders et al. 1997</td>
</tr>
<tr>
<td>4</td>
<td>Wood chips</td>
<td>$2.4 \times 10^{-2}$ - $8.4 \times 10^{-2}$</td>
<td>Ghane et al. 2014</td>
</tr>
<tr>
<td>5</td>
<td>Coarse Sand</td>
<td>$10^{-4}$ - $10^{-2}$</td>
<td>Cabalar &amp; Akbulut 2016; Terzaghi &amp; Peck 1964</td>
</tr>
<tr>
<td>6</td>
<td>Fine Sand</td>
<td>$10^{-9}$ - $10^{-5}$</td>
<td>Cabalar &amp; Akbulut 2016; Terzaghi &amp; Peck 1964</td>
</tr>
<tr>
<td>7</td>
<td>EPS geofoam</td>
<td>Impermeable (&lt;$10^{-9}$)</td>
<td>Akay et al. 2013</td>
</tr>
</tbody>
</table>

\(^a\) New and old wood chips

**Conclusion:** TDA is an excellent free draining material that is used as drainage layers for highways, stormwater systems, daily cover layers for landfills, and subgrade support during the spring thaw.
Roadways
1998-Virgo Street
• The underlying soils were inadequate to support the everyday traffic in front of city hall.

• A lightweight aggregate was required to span the heavy weight soils of the old lakebed.

• TDA is a lightweight option that also prevents frost heave.
Highways
• After soil testing was completed, the geotechnical engineer determined that approximately 350-feet of the new roadway between Freeman Drive and HWY 169 would need to be constructed on lightweight fill.

• Several options were considered, but TDA was chosen for this application.
Hwy 169 | St. Peter | Present
• Tire Rubber Modified Binder
• Utilized for Hot Applied Chip Seal
• And
• As a Binder in Specialized Hot Mix Materials
There are Different Ranges of Pavement Condition (PCI) to Consider When Specifying Pavement Preservation Systems...
From This . . .

To This . . .

How Do We Decide?
Blending and Manufacture
Application
Hot Applied Chip Seal Utilized on Pavements That Have Lower PCI – Expand Your Chip Seal Program
2021 RCMS Project Outreach

- **Video**
  - [FINAL - 100 Miles of Rubber Chip Seal.mp4 - Google Drive](#)
Questions & Contact Information

Kirsten Clemens, P.E.
EGLE - Scrap Tire Coordinator
EGL-ScrapTire@Michigan.gov
517-614-7431

Monte Niemi
TDA Manufacturing
tdamanufacturing@gmail.com
763-444-6017

Jeff Smith
Cactus Asphalt
jsmith@cactusasphalt.com