Assessing the ability of hardwood and softwood brush mats to distribute applied loads

Asst. Prof. Dr. Eric R. Labelle - Technische Universität München
Prof. Dr. Dirk Jaeger - Universität Freiburg
Mr. Benjamin J. Poltorak, MScF

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Outline

- Background and problem statement
- Research objectives
- Methodology
- Results and discussion
- Conclusion
Background and problem statement

- Increased importance of mechanized forest operations

- Harvesting residue (brush) can be used as a soil protective layer

- The effect of brush quantity on load distribution is well documented but more information on the influence of brush quality is needed
Research objectives

- Determine and quantify the difference in loading resistance between HW and SW small-scale brush mats of different amounts compared to no brush.

- Quantify the effect of repetitive loadings of brush mats on their ability to reduce strain recorded beneath the mats.
Methodology

- Three strain gauges were installed on separate steel channels at the bottom of the load box.

- Strain gauges were covered by a 15 cm layer of sand to equally assess load distributing capabilities of different brush amounts.
<table>
<thead>
<tr>
<th>Brush amount</th>
<th>Test series</th>
<th>Loading events</th>
<th>Applied loads (kN)</th>
<th>Brush mat measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 kg m(^{-2})</td>
<td>Test series 1</td>
<td>Consolidation loading</td>
<td>0</td>
<td>Thickness (cm)</td>
</tr>
<tr>
<td>20</td>
<td>0.09</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Loading events**

- Main-test loading
- Consolidation loading
- Release load and allow brush to rebound

**Applied loads (kN)**

- 0
- 0.09
- 10
- 10
- 20
- 20
- 30
- 30
- 40
- 40

**Brush mat measurements**

- Water content
- Thickness (cm)

**Hardwood (HW)**

- Test 1: 10
- Test 2: 10
- 20
- 30
- 40

**Softwood (SW)**

- Test 1: 10
- Test 2: 10
- 20
- 30
- 40

**Conversion**

- 0.09 kN = 4.8 kPa
- 10 kN = 537 kPa
Results

Consolidation loading

Main-test loading
### Response of middle gauge

#### Hardwood

<table>
<thead>
<tr>
<th>kg m⁻²</th>
<th>20 kg m⁻²</th>
<th>30 kg m⁻²</th>
<th>40 kg m⁻²</th>
</tr>
</thead>
<tbody>
<tr>
<td>με</td>
<td>123.0 ab</td>
<td>80.5 bc</td>
<td>61.9 c</td>
</tr>
<tr>
<td></td>
<td>63.5</td>
<td>62.1</td>
<td>61.6</td>
</tr>
</tbody>
</table>

| με     | 296.0 ab  | 224.9 b   | 177.0 b   |
|         | 65.7      | 74.0      | 79.5      |

#### Sand

<table>
<thead>
<tr>
<th>kg m⁻²</th>
<th>0 kg m⁻²</th>
<th>10 kg m⁻²</th>
<th>20 kg m⁻²</th>
<th>30 kg m⁻²</th>
<th>40 kg m⁻²</th>
</tr>
</thead>
<tbody>
<tr>
<td>με</td>
<td>337.0</td>
<td>125.8 a</td>
<td>112.7 ab</td>
<td>75.1 bc</td>
<td>60.1 c</td>
</tr>
<tr>
<td>(%)</td>
<td>100.0</td>
<td>62.1</td>
<td>66.6</td>
<td>67.7</td>
<td>62.2</td>
</tr>
</tbody>
</table>

| με     | 864.1    | 292.8 a   | 261.8 ab  | 214.5 bc  | 186.4 c   |
| (%)    | 100.0    | 66.1      | 69.7      | 75.2      | 78.4      |

#### Softwood

<table>
<thead>
<tr>
<th>kg m⁻²</th>
<th>0 kg m⁻²</th>
<th>10 kg m⁻²</th>
<th>20 kg m⁻²</th>
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<th>40 kg m⁻²</th>
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<tr>
<td>με</td>
<td>1310.0</td>
<td>369.5 a</td>
<td>320.5 ab</td>
<td>266.0 bc</td>
<td>233.0 c</td>
</tr>
<tr>
<td>(%)</td>
<td>100.0</td>
<td>71.8</td>
<td>75.5</td>
<td>79.7</td>
<td>82.2</td>
</tr>
</tbody>
</table>

### % reduction compared to sand
### Response of side gauges

#### Hardwood

<table>
<thead>
<tr>
<th></th>
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<th>10 kg m(^{-2})</th>
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<tr>
<td><strong>Sand</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>(με) 17.2</td>
<td>39.3 a</td>
<td>34.4 ab</td>
<td>24.2 bc</td>
<td>16.9 c</td>
</tr>
<tr>
<td></td>
<td>(%) 5.1</td>
<td>31.1</td>
<td>24.0</td>
<td>18.5</td>
<td>12.8</td>
</tr>
<tr>
<td>5</td>
<td>(με) 53.9</td>
<td>109.8 a</td>
<td>100.2 a</td>
<td>85.2 a</td>
<td>75.5 a</td>
</tr>
<tr>
<td></td>
<td>(%) 6.2</td>
<td>37.5</td>
<td>38.3</td>
<td>39.7</td>
<td>40.5</td>
</tr>
<tr>
<td>10</td>
<td>(με) 51.8</td>
<td>147.0 a</td>
<td>130.0 a</td>
<td>109.5 a</td>
<td>100.5 a</td>
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<tr>
<td></td>
<td>(%) 4.0</td>
<td>39.8</td>
<td>40.6</td>
<td>41.2</td>
<td>43.1</td>
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Conclusion

- Small-scale brush mats reduced strain directly below loading disk and increased lateral strain.

- SW brush mats performed slightly better than HW mats.

- Further studies with full-scale (unconfined) brush mats of varying species and branch water contents should be performed.
Thank you - Vielen Dank!

Asst. Prof. Dr. Eric R. Labelle
Email: eric.labelle@tum.de
Office phone: 08161.71.4760

Prof. Dr. Dirk Jaeger
Email: dirk.jaeger@foresteng.uni-freiburg.de
Office phone: 07612.03.3567
Appendices
TOP VIEW

Flange
Steel channel

All dimensions are in millimeters

Steel base plate 6.4 mm thick
Strain gauge located underneath channel
Connection wires

4.8 x 14.3 bolt counter sunk into flange

SIDE VIEW

SCALE EXAGGERATED

All dimensions are in millimeters

Chase 3.2 high x 6.4 wide

Steel channel (25.4 wide x 6.4 thick)
Flange

Steel base plate