Pilot application of modified asphalt mixture with End of Life Tires (ELTs) and Reclaimed Asphalt Pavement (RAP)
According to the European Tyre & Rubber Manufactures Association (ETRMA) approximately 3 million tons of end-of-life tyres (ETL) are produced, in the European Union, with a cycle utilization of 92%.

In addition, 50 million tons of reclaimed asphalt pavement (RAP) are recovered annually in the European Union, which can be reused in the construction of new roads, as well as in the maintenance of existing ones.
One of the least common applications of ELT’s, in the EU, is to modify the asphalt with crumb rubber that is derived from their mechanical treatment.

This use achieves:
- 100% tire recycling
- A significant contribution to the circular economy.
RECLAIMED ASPHALTS PAVEMENT - RAP

- Material from the removal of asphalt pavement (asphalt and aggregates)
- Contains high quality aggregate covered in asphalt
- Typical use of RAP up to 30%
- Main barrier:
  - ↑ asphalt stiffness
The RAP-ELT project studied the possibility of increasing the recycling rate of Reclaimed Asphalt Pavement (RAP) in the production of asphalt mixtures due to the modification of asphalt with rubber granulate, aiming the:

• Production of Asphalt pavement with superior characteristics
• Utilization of two waste flows (ELT & RAP)
• Utilization of ELTs with techniques more environmentally efficient compared to energy recovery
(A) Dry Method
Uses Styrene Butadiene Rubber - SBR (size 2/4mm) instead of aggregates (3% by weight) directly in the asphalt mixing plant

(B) Wet Method
Uses SBR (size 0/0.4mm) instead of Styrene Butadiene Styrene - SBS as elastomeric modifier (<20% w/v) in modified asphalt plant and then transferred to asphalt mix plant
**ASPHALT MODIFICATION METHODS**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dry Methods</th>
<th>Wet Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Flexibility</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Production Cost</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SBR Incorporation</td>
<td>✓ (&lt;30 Kg/tn)</td>
<td>(&lt;1 Kg/tn)</td>
</tr>
<tr>
<td>Production Process Certification</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

**Dry Method**
Composition based on the Marshall Method (Aggregate, RAP, Asphalt*, SBR 2/4mm < 3%)

Failure to produce a sample at **150°C**

**Wet Method**
Composition based on the Marshall Method
Production of Modified Asphalt (Asphalt*, SBR Powder 0/0.4mm)

#4+1 Samples
0 – 5 – 10 – 15 – 20 % w/w
A pilot application of a heavy traffic road was occurred in the Municipality of Aspropyrgos. Asfalter produced 4 different asphalt mixtures using conventional asphalt, modified asphalt, primary aggregates and secondary aggregates (RAP) accordingly. The modified asphalt was delivered to the asphalt plant of Asfalter SA. The crumb rubber (5% w/w of modified asphalt) and the asphalt was mixed in a low shear mixer at 180°C until homogenized. The crumb rubber was delivered to Netoil SA. ELTs was grinded in RETIRE SA. Asfalter produced 4 different asphalt mixtures using conventional asphalt, modified asphalt, primary aggregates and secondary aggregates (RAP) accordingly. A pilot application of a heavy traffic road was occurred in the Municipality of Aspropyrgos.
A total of 4 consecutive sections were paved along the 300 m long road in Asporyrgos.

- 75 m conversional asphalt
- 125 m modified asphalt mixture with crumb rubber
- 150 m modified asphalt mixture with crumb rubber and 30% RAP
- 150 m modified asphalt mixture with crumb rubber and 50% RAP

The temperature of asphalt mixtures was 170°C.
Two series of Measurements

- May 2021
- September 2021

**Environmental noise measurement**

**Skid resistance measurement**

**Rutting resistance - Wheel bolts measurement**

**Visual observation of splash & spray**

**Expected Results**

- Increased lifetime of the pavement
- Higher resistance in high temperatures (reduced rutting) and low temperatures (reduced cracking)
- Reduced noise from vehicle traffic
- Reduced “spraying” from vehicle traffic on wet roads
→ Skid Resistance (Grip tester)

→ Rutting Resistance – Wheel bolts (Walking Profiler)

→ Environmental Noising (Nti xl2-sound level meter, Bruel & Kjaer 4230-Sound level calibrator)
Splash & Spray: the phenomenon of the ejection of water particles due to the movement of car tires on the wet road surface.

- Conventional Asphalt
  - At conventional wet asphalt, dangerous spraying is created

- Modified Asphalt with Crumb Rubber
  - At modified wet asphalt the spraying is reduced
Skid resistance is the result of the friction that develops between the road surface and vehicle tires. Increased friction value → increased resistance to sliding → greater safety.
Grip Number  B67str. FROM ASFALTER to NATO AV.
COMPARISON

Grip number ↑ ↔ Rolling resistance ↑

- 3/9/2021 Conventional asphalt mix
- 22/05/2021 Conventional asphalt mix
- 3/9/2021 Modified asphalt mix & 50% RAP
- 22/05/2021 Modified asphalt mix & 50% RAP
- 3/9/2021 Modified asphalt mix & 30% RAP
- 22/05/2021 Modified asphalt mix & 30% RAP
- 3/9/2021 Modified asphalt mix
- 22/05/2021 Modified asphalt mix
Rutting created mainly due to the increased traffic of vehicles as well as due to their heavy weight.
**Noising Size and Type of aggregates**

**Type of asphalt mixture**

**Aging of the pavement**

**Thickness & Texture of the road surface**

**Pavement porosity**

**Speed of the vehicle**

**Temperature**

**Noising**

**Crumb rubber → Porosity increase**

**Greater porosity → Greater absorption → Lower noise levels**

**Modified asphalt mixture with crumb rubber**

**Modified asphalt mixture with crumb rubber and 30% RAP**

**Modified asphalt mixture with crumb rubber and 50% RAP**

**Conventional asphalt mixture**

**Modified asphalt mixture with crumb rubber and 30% RAP**

**Modified asphalt mixture with crumb rubber**
RESULTS - CONCLUSIONS

- **Skid Resistance**: Best performance: Modified asphalt mix with crumb rubber
- **Rutting resistance**: No significant differences between modified mixes
  - Rutting: Conventional asphalt mix
- **Noising**: Best performance: Modified asphalt mixture with crumb rubber
- **Splash & Spray**: Best performance: Modified asphalt mixture with crumb rubber
## COST ANALYSIS

(2000 $m^2$)

<table>
<thead>
<tr>
<th></th>
<th>Conventional asphalt</th>
<th>Modified asphalt mixture with crumb rubber</th>
<th>Modified asphalt mixture with crumb rubber and 30% RAP</th>
<th>Modified asphalt mixture with crumb rubber and 50% RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of old asphalt</td>
<td>2.850,00 €</td>
<td>2.850,00 €</td>
<td>2.850,00 €</td>
<td>2.850,00 €</td>
</tr>
<tr>
<td>Application of adhesive coating</td>
<td>900,00 €</td>
<td>900,00 €</td>
<td>900,00 €</td>
<td>900,00 €</td>
</tr>
<tr>
<td>Paving of asphalt mixture</td>
<td>15.228,00 €</td>
<td>17.549,46 €</td>
<td>16.442,95 €</td>
<td>15.557,13 €</td>
</tr>
<tr>
<td>Total Cost</td>
<td>18.978,00 €</td>
<td>21.299,46 €</td>
<td>20.192,95 €</td>
<td>19.307,13 €</td>
</tr>
<tr>
<td>Total Cost per $m^2$</td>
<td>9,49 € +RAP disposal cost</td>
<td>10,65 €</td>
<td>10,10 €</td>
<td>9,65 €</td>
</tr>
<tr>
<td>Total Cost per tn</td>
<td>82,66 €</td>
<td>91,73 €</td>
<td>86,33 €</td>
<td>81,98 €</td>
</tr>
</tbody>
</table>
## LIFE CYCLE ASSESSMENT (2000 m²)

<table>
<thead>
<tr>
<th></th>
<th>Conventional asphalt</th>
<th>Modified asphalt mixture with crumb rubber</th>
<th>Modified asphalt mixture with crumb rubber and 30% RAP</th>
<th>Modified asphalt mixture with crumb rubber and 50% RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt mixture</td>
<td>5,42</td>
<td>6,21</td>
<td>5,35</td>
<td>4,68</td>
</tr>
<tr>
<td>Emulsion</td>
<td>0,36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot application</td>
<td>0,25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total emissions</td>
<td>6,03</td>
<td>6,82</td>
<td>5,96</td>
<td>5,29</td>
</tr>
<tr>
<td>Total emissions</td>
<td>26,26</td>
<td>29,37</td>
<td>25,48</td>
<td>22,46</td>
</tr>
<tr>
<td>CO₂ per tn asphalt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions savings</td>
<td></td>
<td>11,84</td>
<td>-2,97</td>
<td>-14,47</td>
</tr>
<tr>
<td>CO₂ (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NEXT STEPS

1. Additional measurements after a longer period of time
2. Scaling up the pilot application (longer length of asphalt road, study of intersections etc.)
3. Introduction to national specifications
Thank you!