Towards wide-spread use of Recycled Tyre Rubber modified bitumen in road pavements

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Potted history of pavement engineering research at Nottingham

· Pavement engineering research undertaken at Nottingham since 1954
· Leadership of Professor Peter Pell & Professor Stephen Brown
· Nottingham Centre for Pavement Engineering (NCPE) formed in 2001
· Expanded into new areas and changed name to Nottingham Transportation Engineering Centre (NTEC) in 2007
Group and Facilities

Professor Gordon Airey
Director

The Pavement Research Building is a purpose-built £2.4m state-of-the-art centre for research and development in all areas of pavement engineering - design, performance, maintenance and materials.

- 5 academics
- 3 Post-docs
- about 30 PhD students
- 5 technicians

www.nottingham.ac.uk/ntec

Nottingham Transportation Engineering Centre (NTEC) – Research Themes

Application Sectors

- Road
- Rail
- Air

Research Themes

- Materials
- Design & Performance
- Asset Management
- Operational Risk & Reliability
- Sustainability & the Environment
Sustainable Engineering

Developing best practices and maximize recycling by minimizing the impact

Technologies development

Secondary materials
Tyres
Testing
Modelling
On-site Experience
Design

Maximise recycling

Minimise impact

Sustainability Assessment

- Sustainability metrics
- Performance based evaluation
- Life Cycle Assessment (LCA)
- Life Cycle Cost Analysis (LCCA)

http://superitn.eu

FP7 (2013 – 2017) grant n.607524

H2020 (2017 – 2021) grant n.721493

http://smartietn.eu
Presentation Outline

• Introduction

• Part 1: Rubberised Road Pavements: Why don’t we use them extensively?

• Part 2: Recycled Tyre Rubber Modified bitumen – RTR MB
  ✓ Technologies and Processing conditions
  ✓ Manufacturing, Rheology and Quality Control
  ✓ Towards more reliable viscosity measurement of RTR-MB and Computational rheology

• Q&A 2 - 5 mins

Why don’t We extensively use Rubberised asphalt concrete??
ELT waste or resource?

- End of life tyres (ELTs) are among the largest and most problematic sources of waste, due to the large volume produced and their durability.

- About 1.4 billion tyres are sold worldwide each year and subsequently as many eventually fall into the category of ELTs.

- Furthermore, the amount of ELTs in Europe, US and Japan are about to increase because of the projected growing number of vehicles and increasing traffic worldwide.

ELT waste or resource?

- Those same characteristics which make waste tyres such a problem also make them one of the most re-used waste materials as the rubber is very resilient and can be reused in other products.
"The tyre is a complex and high-tech safety product representing a century of manufacturing innovation, which is still ongoing. The tyre comprises many materials, the very best the metallurgical, textile and chemical industries can produce. [...] From a materials point of view, the tyre is a mixture of synthetic and natural rubber, to which are added a range of specific substances to ensure performance, durability and safety (Shuman, 2000)."

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**ELT waste or resource?**

### End of Life Tyres as a material:

- **processing ELTs:**
  - Shreds: 200 mm
  - Chips: 40 mm
  - Ground granulate: 1-3 mm
  - Ground powder: 0.5-1 mm

  **Specified physical and chemical properties**

- **many applications:**

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**One of the most successful applications is the use of RTR in asphalt concrete for road pavements.**

**How come??**
Romans pavements
Primary purpose of these roads was for foot soldiers, so the roads were straight, they generated high noise levels, were rough and labor intensive.

Summa Crusta (surfacing): Smooth, polygonal blocks bedded in underlying layer.

Nucleus: A kind of base layer composed of gravel and sand with lime cement.

Rudus: The third layer was composed of rubble masonry and smaller stones also set in lime mortar.

Statumen: Two or three courses of flat stones set in lime mortar.

Modern Road Pavement
Primary purpose is for freight and passenger movements. Roads must ensure comfortable journey for the passengers, do not damage vehicles and have reduced impact on the vicinities (dust, noise, etc..)
Flexible Pavement - ASPHALT CONCRETE for Surface and Base

Asphalt Concrete is a material manufactured by playing with aggregate, bituminous binders and the ratio between the two. The operation of optimising these variables is named “Mix design”. The final mix should be manufactured to have:

- Permanent Deformation resistance
- Fatigue resistance
- Low temperature cracking resistance
- Durability (ageing)
- Moisture damage resistance
- Workability
- Skid Resistance, etc, etc

Basics of Road Pavement

RTR in Road Asphalt Pavement

Crumb Rubber
Ground & Powder rubber max 2-3 mm

- Ambient grinding
- Cryogenic process
- Waterjet
- Other

DRY process

WET Process
RTR-MB in Road Asphalt Pavement

Wet Process:
Recycled Tyre Rubber Modified Bitumen

- Viscosity@177 ºC: 1500 – 5000 cP
- Usually a Low shear process
- Non-Homogeneous material
- Unstable at Hot storage
- Some issues and limitations, but overall a worldwide used product with very good performance

RTR-MB in Road Asphalt Pavement

Anti-cracking membrane:
Stress absorbing membrane interlayer (SAMI)

- Used to prevent reflective cracking
- 20% to 23% rubber by weight of virgin binder
- 1,500 to 1,700 tyres per kilometer of a two-lane highway
RTR-MB in Road Asphalt Pavement

Rubber modified asphalt (functional - surface)

• Rubber-Modified Open-Graded Friction Course
  Used to decrease noise, increase skid resistance, and increase surface drainage
  ✓ Roughly 93% aggregate, **9% asphalt binder**, and NO fibers
  ✓ 12% to 20% rubber by weight of virgin binder
  ✓ 700 to 1,200 tyres per kilometer of a two-lane highway

Rubber modified asphalt (functional and structural)

• Rubber-modified dense-graded friction course (R-M DGFC)
  5% to 10% rubber by weight of virgin binder

• Rubber-modified gap-graded friction course (R-M GGFC)
  18% to 20% rubber by weight of virgin binder
  ✓ Similar to SMA
  ✓ Roughly 5-7% **asphalt binder** and 95% aggregate
  ✓ 500 to 2,000 tyres per kilometer of a two-lane highway
RTR-MB in Road Asphalt Pavement

The secret of Rubber modified asphalt

<table>
<thead>
<tr>
<th>Type</th>
<th>Binder properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Graded 4.6% HMA</td>
<td>Increased binder elasticity at high temperatures</td>
</tr>
<tr>
<td>9 Micron</td>
<td>Increased binder viscosity</td>
</tr>
<tr>
<td>Gap Graded 7.4%</td>
<td>allows greater film thickness in paving mixes</td>
</tr>
<tr>
<td>Asphalt Rubber 18 Micron</td>
<td>without excessive drain down or bleeding.</td>
</tr>
<tr>
<td>Open Graded 9.2%</td>
<td>Provides to mixtures significantly improved</td>
</tr>
<tr>
<td>Asphalt Rubber 36 Micron</td>
<td>engineering properties over conventional</td>
</tr>
<tr>
<td></td>
<td>paving grade bitumen</td>
</tr>
</tbody>
</table>

- Reduced maintenance costs
- Lower noise generation
- Improved resistance to rutting
- Reduced temperature susceptibility.
- Improved aging and oxidation resistance
- Reduced construction times, and material amount due to thinner lifts, etc.
RTR-MB in Road Asphalt Pavement

- **Limitations & issues**
  - Higher cost of production compared to asphalt with conventional bitumen
  - It is not possible to store High Viscosity TR-MB at elevated temperatures without special equipment (higher initial cost because of plant modifications)
  - Asphalt pavement construction may be more challenging.
  - Reduced asphalt thickness
  - **Emission with odour**, also if it **seems to not be harmful**. Recently very much reduced by using warm mix additives
  - Binder cannot be stored for long time at high temperature (ideally not more than 48 hours after blending) because of over-digestion
  - **Recyclability.** Some study have demonstrated that that asphalt rubber can be recycled using either microwave technology or conventional mix design technology. However, there is still the need of further research

RTR in Road Asphalt Pavement

- Wet process Rubberised asphalt concrete is a **long-lasting working technology** that works as fine as high-performing asphalts (PMBs) and allows re-using high volumes of tyres

*Why don’t We extensively use Rubberised asphalt concrete??*
Activities on Tyre Rubber Recycling

- Plant up-scaling Assistance
- Process Quality control

- Roofing membranes (since 2013)

- Road pavements (since 2008)

- Railway sub-ballasts (since 2011)

Recycled Tyre Rubber Modified bitumen

Technologies and Processing conditions
The “quiet come back” of TR in asphalt
Thanks to policies as ISTEA 1991 (USA), EC 2008 (EU), California 2009 (USA)

**HIGH VISCOSITY**
- Viscosity@177°C: 1500 – 5000 cP
- Basically a Low shear process
- Non-Homogeneous material
- Unstable at Hot storage
- Some issues and limitations, but overall a worldwide used product with very good performance

**NO-AGITATION**
- Viscosity@177°C: 500-1000 cP
- High curing conditions
- Homogeneous material (CRM solubility higher than 97%)
- Storage stable
- No particular issues or operative limitations apart: Performance ???

2 different products (Caltrans 2006)
- Wet process - High Viscosity
- Wet process – No Agitation

2 processing systems:
- McDonald process
- Continuous Blending

started in the 1960s

Digestion through Swelling process. Many benefits thanks to increased elasticity at high temperatures and increased viscosity that allows greater film thickness in paving mixes.
2 different products (Caltrans 2006)

- Wet process - High Viscosity
- Wet process – No Agitation

2 processing systems:

- McDonald process
- Continuous Blending

The idea with Tyre Rubber binders produced with the NO agitation-wet process, also famous as Terminal Blend binders, is to produce a material in which the tire rubber is fully digested, or better dissolved, into the bitumen without leaving visibly discrete particles. The characteristic swelling process of the previously mentioned TR-MB technologies is replaced by the depolymerisation/devulcanization and optimised dispersion of the rubber into the bitumen by using high processing temperature (over 200 ºC) and high shear stress during the mixing, resulting in a smooth, homogeneous product.

started in the mid-1980s
2 different products (Caltrans 2006)
- Wet process - High Viscosity
- Wet process – No Agitation

2 processing systems:
- McDonald process
- Continuous Blending

TR-MB like a PMB
Cured with High processing conditions

RTR-MB: Technologies and Processing conditions

The interaction between bitumen and CRM materials is material-specific and depends on a number of basic factors, including:

**Processing variables**
- Processing Temperature
- Processing Time
- Processing Device (applied shear stress)

**Materials**
- Base binder (physical and chemical prop)
- Rubber Type
- Rubber Source (processing methods)
- Rubber Gradation
- Rubber Particle size

*mainly a physical phenomenon (swelling)*
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penetration: dmm</td>
<td>85-100</td>
<td>120-150</td>
<td>120-150</td>
<td>85-100</td>
</tr>
<tr>
<td>Crumb rubber requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passing sieve: mm</td>
<td>2.36</td>
<td>2.36</td>
<td>1.18</td>
<td>2.36</td>
</tr>
<tr>
<td>Rubber content: %</td>
<td>&gt; 15</td>
<td>18-22</td>
<td>18-24</td>
<td>15-18</td>
</tr>
<tr>
<td><strong>Additives</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extender oils: %</td>
<td></td>
<td>2.5 - 6</td>
<td>0 - 4</td>
<td></td>
</tr>
<tr>
<td>Calcium carbonate / Talc: %</td>
<td>0 - 4</td>
<td>0 - 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Processing variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature: °C</td>
<td>180</td>
<td>190-220</td>
<td>180-220</td>
<td>195</td>
</tr>
<tr>
<td>Mixing speed: rpm</td>
<td>basically low shear</td>
<td>Low shear</td>
<td>3000 rpm + low shear</td>
<td>Low shear</td>
</tr>
<tr>
<td>Mixing time: min</td>
<td>45</td>
<td>45-60</td>
<td></td>
<td>30-45</td>
</tr>
</tbody>
</table>

Austroads laboratory procedure for Crumb rubber modified binders (AP-T42, 2006)

**Laboratory testing always necessary!**
- a priori: binder design
- a posteriori: property check
Superior binder design?
↓
Good selection of materials
↓
Efficiently monitoring the effect of varying processing conditions

Rheology

Recycled Tyre Rubber Modified bitumen

Manufacturing, Rheology and Quality Control
**RTR-MB: Manufacturing, Rheology and Quality control**

*Material design: Viscosity (apparent) is a Key factor*

![Graph showing viscosity over time at elevated temperatures with an optimum point](image)

- **(a) Binder viscosity**
- **(b) Binder matrix**
- **(c) Particles size**

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**Low-shear blending protocol:**

- It has to be simple to perform,
- Consumes the smallest amount of material possible and
- Temperature has to be well controlled
- Controlling and optimizing the modification process of bitumen with rubber

**Rotational Viscometer → Low shear mixer**

- 10-15 g of material
- 1 day
- Temperature control
- Monitoring viscosity

Dynamic Mechanic Analysis (DMA)

Rheological characterization of all the binders was done by performing frequency sweeps tests with an Antoon Paar Physica MCR 101 under the following conditions:

- Mode of loading: controlled-strain
- Temperatures: 30°C to 80°C at 5°C intervals
- Frequencies: 0.10, 0.16, 0.25, 0.40, 0.63, 1, 1.6, 2.5, 4, 6.3 and 10 Hz
- Spindle geometries: PLATE - PLATE 8 mm φ and 2 mm gap (0-45°C), 25 mm φ and 1-2 mm gap (35-80°C)
- Strain amplitude: 0.5% (within LVE response dependent on G*)
RTR-MB: Manufacturing, Rheology and Quality control

DSR tests

Data reliability

- Gap setting
- Machine compliance
- Equilibrium time
- Calibration and maintenance

![Data reliability diagram](image)

RTR-MB: Manufacturing, Rheology and Quality control

Design & Performance

![Design & Performance diagram](image)

Results:

Material properties optimisation

Definition of a laboratory optimisation protocol for road bitumen improved with recycled tire rubber. Construction and Building Materials, 37, 562-572.

Low shear protocol: High Temperatures DMA

**Results:**
- Higher TR% → better high temperature properties
- 18 – 24% similar properties → STOPPED
Optimum TR content:

- Phase angle is constantly lower than 70°C,
- Phase angle master curves and isochronal plots achieve a plateau or a downward trend at low frequencies (high temperatures);
- TR-MB show a high critical temperature over 80°C (measured with SHRP or Shenoy’s parameter).

18% TR content for both temperature

High shear production
Temperature controlled bath

- Silverson High shear mixer L5M with duplex head
- Thermostatic bath with oil temperature control = NO MORE DISCREPANCIES
- 1 - 4 Kg of material needed!

RTR-MB: Manufacturing, Rheology and Quality control

High shear protocol

Temperature controlled bath

High shear blends

- same bitumen: UB01
- same rubber content 18%
- same total mix time: 120 min

<table>
<thead>
<tr>
<th>bitumen mass (g)</th>
<th>rubber mass (18% of bit. mass)</th>
<th>total weight (g)</th>
<th>mixing time (m)</th>
<th>mixing speed (rpm)</th>
<th>mixing temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2890</td>
<td>520</td>
<td>3410</td>
<td>120</td>
<td>3500 - 5000</td>
<td>180/210</td>
</tr>
</tbody>
</table>

Rheology: DMA

Apparent viscosity

Blank Diagrams

180 LS: 120min
HS: 40-60min

180 HS: 20 - 40 min
Comparison with PMBs

- HS similar to PMBs
- HS210 worst at (40min)/(120 min)

Time optimisation!!!!

<table>
<thead>
<tr>
<th>Bitumen</th>
<th>RTR-MB</th>
<th>HS180</th>
<th>TR-MB</th>
<th>HS210</th>
<th>SBS-MB</th>
<th>SBS-MB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration 25°C (mm/10) (EN 1426)</td>
<td>50</td>
<td>52</td>
<td>37</td>
<td>51</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Softening Point (°C) (EN 1427)</td>
<td>51</td>
<td>62</td>
<td>55</td>
<td>64</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Penetration Index</td>
<td>-0.96</td>
<td>0.38</td>
<td>-0.70</td>
<td>1.84</td>
<td>4.81</td>
<td></td>
</tr>
<tr>
<td>Apparent Viscosity at 177°C (Pa s) (ASTM D6114)</td>
<td>-</td>
<td>3.500</td>
<td>2.600</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Viscosity at 135°C, (Pa s) (EN 13302)</td>
<td>0.429</td>
<td>5.950</td>
<td>3550</td>
<td>1.290</td>
<td>2.450</td>
<td></td>
</tr>
<tr>
<td>Viscosity at 160°C, (Pa s) (EN 13302)</td>
<td>0.139</td>
<td>2.300</td>
<td>1.120</td>
<td>0.472</td>
<td>0.742</td>
<td></td>
</tr>
</tbody>
</table>

Conventional properties
Conclusions

- Rheological characterisation (DMA) is necessary for a SUPERIOR DESIGN of Tyre Rubber modified binders, but it is fundamental to check data reliability.
- Optimisation of TR-MB is only possible by efficiently monitoring the modification process.
- TR-MB could have very similar properties to SBS-MB, but a binder design procedure is necessary: accurate selection of materials and processing conditions.
- Low Shear Protocol + DMA proved to be a very useful tool to optimise design process, also if improvable.

With the addition of a couple of tests for as:
- Storage stability
- Rubber concentration/solubilization

This system represents a comprehensive approach to efficiently monitoring the blends properties for a superior design of any tyre – rubber blend before mix testing or field application.
Recycled Tyre Rubber Modified bitumen

Towards improved viscosity measurements and computational rheometry

How do we measure viscosity?

Definitions

- Fluid Viscosity
  - Resistance to fluid flow
Definitions

- Fluid Viscosity
  - Resistance to fluid flow

How do we measure viscosity?

How do we measure viscosity?

Bitumen
- Motor and thermal chamber
- Coaxial cylinders
- Torque applied

Viscosity
How do we measure viscosity?

Definitions

- Fluid Viscosity
  - Resistance to fluid flow

- Viscosity with Brookfield Rotational Viscometer – coaxial cylinders geometry
  - Internal Resistance proportional to the torque applied to the fluid through an impeller (spindle)
  - Proportional to Geometry and speed

* Designed for homogeneous/stable fluids
* What happens with complex fluids?

Towards more reliable viscosity measurement of RTR-MB (2014)

Processing Tyre Rubber – Bitumen blends

- 180 – 220 °C – bitumen very low viscosity, 10 cP
- Tyre rubber slight higher density

Graphical representation of viscosity vs. temperature for various substances.
Towards more reliable viscosity measurement of RTR-MB (2014)

- Standard-Viscosity Fluid 10 cP @ 25°C
- 30# tyre rubber crumbs
- Glass Brookfield container

100 RPM

min 0

Towards more reliable viscosity measurement of RTR-MB (2014)

- Standard-Viscosity Fluid 10 cP @ 25°C
- 30# tyre rubber crumbs
- Glass Brookfield container

100 RPM

min 2
Towards more reliable viscosity measurement of RTR-MB (2014)

100 RPM

- Standard-Viscosity Fluid 10 cP @ 25°C
- 30# tyre rubber crumbs
- Glass Brookfield container

min 6

Towards more reliable viscosity measurement of RTR-MB (2014)

100 RPM

- Standard-Viscosity Fluid 10 cP @ 25°C
- 30# tyre rubber crumbs
- Glass Brookfield container

min 11
Towards more reliable viscosity measurement of RTR-MB (2014)

Dual Helical Impeller (DHI)

Dual Helical Spindle (DHS)

CAD model

Rapid Prototyping (FDM)

316L stainless steel (EDM)
Towards more reliable viscosity measurement of RTR-MB (2014)

100 RPM

- Standard-Viscosity Fluid 10 cP @ 25C
- 30# tyre rubber crumbs
- Glass Brookfield container

Toward more reliable viscosity measurement of RTR-MB

100 RPM

- Standard-Viscosity Fluid 10 cP @ 25C
- 30# tyre rubber crumbs
- Glass Brookfield container
Towards more reliable viscosity measurement of RTR-MB (2014)

100 RPM

- Standard-Viscosity Fluid 10 cP @ 25C
- 30# tyre rubber crumbs
- Glass Brookfield container

min 13

Towards more reliable viscosity measurement of RTR-MB (2014)

100 RPM

- Standard-Viscosity Fluid 10 cP @ 25C
- 30# tyre rubber crumbs
- Glass Brookfield container

min 18
Towards more reliable viscosity measurement of RTR-MB (2014)

<table>
<thead>
<tr>
<th>Movie 1</th>
<th>Movie 2</th>
<th>Movie 3</th>
<th>Movie 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield SC 27</td>
<td>Dual Helical Impeller (DHI)</td>
<td>Rotational + Convective like flow</td>
<td>Dual Helical Impeller (DHI)</td>
</tr>
<tr>
<td>10 RPM</td>
<td>100 RPM</td>
<td>10 RPM</td>
<td>100 RPM</td>
</tr>
<tr>
<td>After 10 mins</td>
<td>After 20 mins</td>
<td>After 10 mins</td>
<td>After 20 mins!!!</td>
</tr>
</tbody>
</table>

Standard tool

Rotational flow

Dual Helical Impeller (DHI)
Towards more reliable viscosity measurement of RTR-MB (2014)

DHI calibration

- Torque measured
- Speed set
- Geometry = Shear Rate Constant

Shear Rate = SRC x SPEED

Shear Rate, Torque, Viscosity

Towards more reliable viscosity measurement of RTR-MB (2014)

Bitumen viscosity (homogeneous material)

- 135°C/SC-27
- 135°C/DHI
- 177.5°C/SC-27
- 177.5°C/DHI

10% accuracy
Towards more reliable viscosity measurement of RTR-MB (2014)

Tyre Rubber – Bitumen (not homogeneus)

Apparent viscosity of a RTR-MB at 177.5°C by using LV viscometer at 50 and 100 rpm

Improving the rheometry of rubberized bitumen: experimental and computation fluid dynamics studies (2016)

Input:
- Multiphase model
- Fluid Viscosity/density
- Particle size/density
- Rotational Speed
- Boundary conditions
- Time (time steep)

Output:
- Particles distribution
- Velocity fields
Improving the rheometry of rubberized bitumen: experimental and computation fluid dynamics studies (2016)

Particle distribution (volume fractions)

High viscosity fluid

Improving the rheometry of rubberized bitumen: experimental and computation fluid dynamics studies (2016)

Particle distribution (volume fractions)

Low viscosity fluid
Improving the rheometry of rubberized bitumen: experimental and computation fluid dynamics studies (2016)

- DHI allows obtaining sample stability allowing more reliable viscosity measurements of complex fluids

- CFD simulations clarified the mechanisms behind the previously assumed convective-like flow created by the DHI.

  ✓ Velocity fields confirms that the central screw of the DHI drags up the complex system while the external screw transports the mixture downwards.

  ✓ with current design, the central screw of the DHI could be more effective at pumping the fluid vertically – this leads the way to enhancements in the design.
DHI optimisation

1. Design
2. CFD analysis performed to validate results
3. Design Optimization

Work in progress…..

Input:
- Multiphase model
- Viscous model
- Materials
- Rotational Speed
- Boundary conditions
- Time (time steep)

Output:
- Velocity fields
- Particles distribution
- Torque ➔ Viscosity
**Work in progress…..**

RTR-MB 180C Viscosity comparison (Experimental Vs Numerical)

- **Sc-27 Numerical**
- **Sc-27 Experimental**
- **DHR Numerical**
- **DHR Experimental**

Max error 13.5%

**Toward more reliable viscosity measurement of RTR-MB**

**CONCLUSIONS**

*Why do We want reliable viscosity measurements?*

- Why not!? Accurate design of Rubberised blends
- What are We measuring right now??
**Toward more reliable viscosity measurement of RTR-MB**

**CONCLUSIONS**

*Why do We want reliable viscosity measurements?*

- Why not!? Accurate design of Rubberised blends
- What are We measuring right now??
- Viscosity key factor for asphalt mix design, manufacturing and compaction
- Rubberised bitumen standards are based on viscosity/rheology measurements!

---

**Why don’t We extensively use Rubberised asphalt concrete??**

**Recommendations for wide-spread applications**

- **High Viscosity Continuous blending system** could be already widely used in any country for trial sections
  - Accurate design is needed
  - Producing only the necessary amount for test sections
  - NO storage (NO modifications to existing asphalt plant)
  - Some issues but Good performance
  - Accurate binder design (a priori)
  - Field blends check
Why don’t We extensively use Rubberised asphalt concrete??

Recommendations for wide-spread applications

- NO agitation + WMA could be the CRACK for the market
- Continuing research on
  - Deeper investigation on blend compatibility:
  - Ageing effect.
  - Assessing long term performance
  - Emissions reduction
  - Technology AVAILABLE!

Why don’t We extensively use Rubberised asphalt concrete??

Some replies:
- Policy makers and Associations should support wide spread use by
  - Policies or technical specifications. Providing contractors with tax benefits for using a recycled product and possibly shifting to performance-based procurement
  - Tyre Industry should help! allowing more budget to tailor products nationally (validation and implementation projects) and training personnel and stakeholders and disseminate good practices (SIGNUS good example)
  - Circular economy. “Linear landfill” is a negative version of something that could be a brilliant piece of sustainable engineering
Thanks for the attention

Dr. Davide Lo Presti

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PROJECT:
“Recycling Tyre Rubber in Civil Engineering applications”