

# Recycling of RAP with Waste Cooking Oil as a rejuvenator in asphalt concrete

Funding:



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be-READY Workshop

9 to 11 May 2023, Oslo, Norway

Partners:



# Presentation Outline

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Introduction

Reclaimed Asphalt Materials (RAP)

Waste Cooking Oil (WCO)

Mix-design

Production of blends and specimens

Asphalt mixtures' properties

Full-scale prototypes

Ongoing developments



# Introduction

- **Project: CoolAsphalt** funded by the European Union and the Portuguese program Portugal 2020 (approx. budget **1M€**)
- **Goals:**
  - ✓ development of asphalt mixtures on an industrial scale with **up to 100% of RAP reuse**, using **WCO** as a rejuvenator.
  - ✓ **low-cost material** that meets acceptable mechanical performance requirements for medium / low-traffic roads.



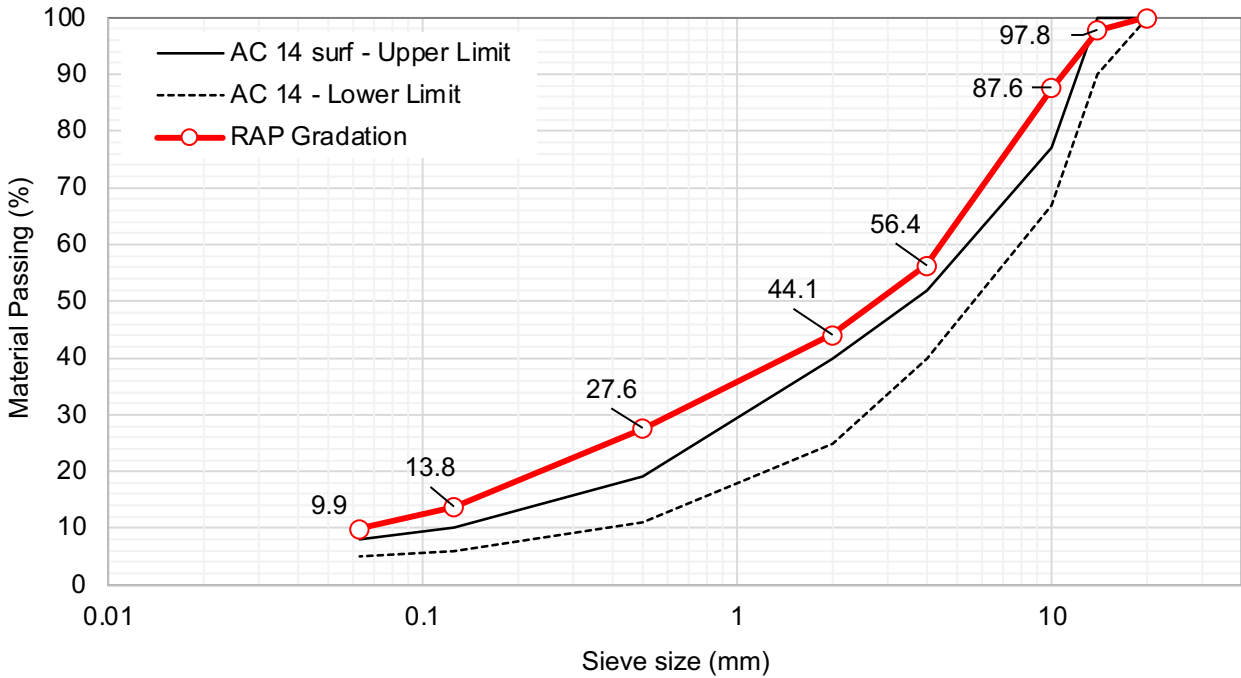
# Reclaimed Asphalt Materials (RAP)

- **Availability:** only part of site-won asphalt generated [approx. 56 M tonnes] in Europe in 2021 has been reused or recycled. [Source: EAPA 2022]

**High reuse rate:** need for rejuvenation of aged RAP bitumen

- ✓ **Ageing:** loss of volatile fractions by exposure to UV radiation, atmospheric oxygen, moisture and temperature variation
- ✓ **Rejuvenating agents:** increase the maltenes/asphaltenes ratio of the aged bitumen, reducing lack of adhesion, stiffness and cracking sensitivity

# Reclaimed Asphalt Materials (RAP)



4.5%  
bitumen

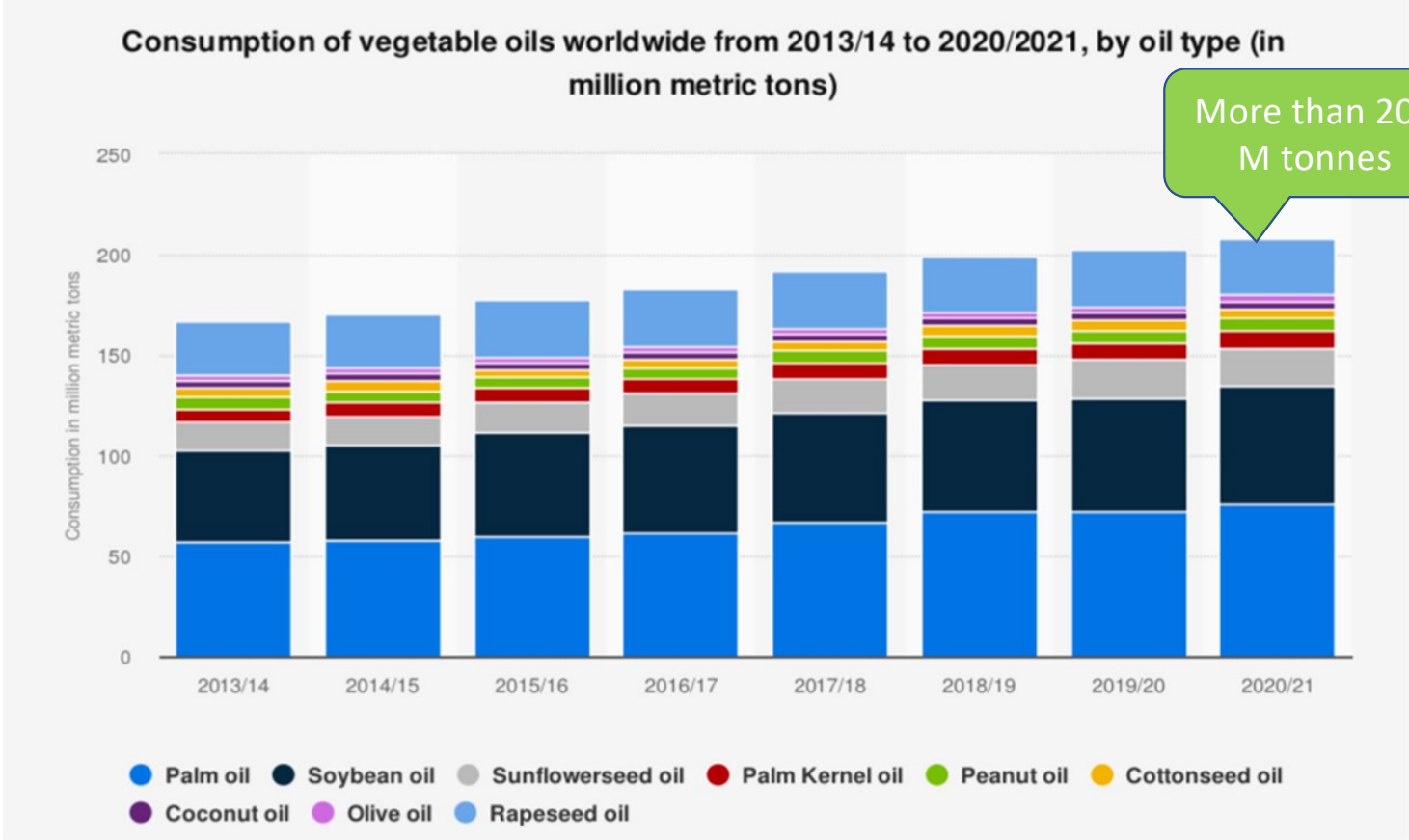
**Aged bitumen:**

**Typical pen<sub>25</sub>: 20 (10<sup>-1</sup> mm)**

**Typical T<sub>R&B</sub>: > 60°C**

# Waste cooking oil

[Source: Zahoor et al. 2021]



# Waste cooking oil

Better **acidity values** (mg KOH/g) for obtaining a binder with suitable rheology at high temperatures:

- ✓ 0.4 to 3.2 mg KOH/g [Source: Zhang *et al.* 2017]

Acidity values of most commonly available WCOs:

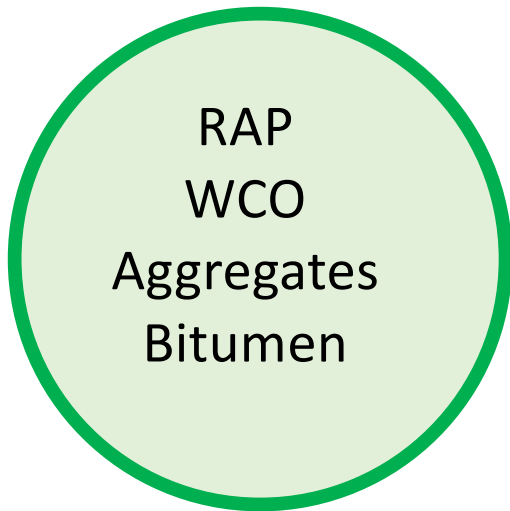
- ✓ 1.32 and 3.6 mg KOH/g [Source: Carlini *et al.* 2014]

Physical treatment to remove some particles or chemical treatment to reduce the acidity of WCO may be necessary [Source: Elahi *et al.* 2014]

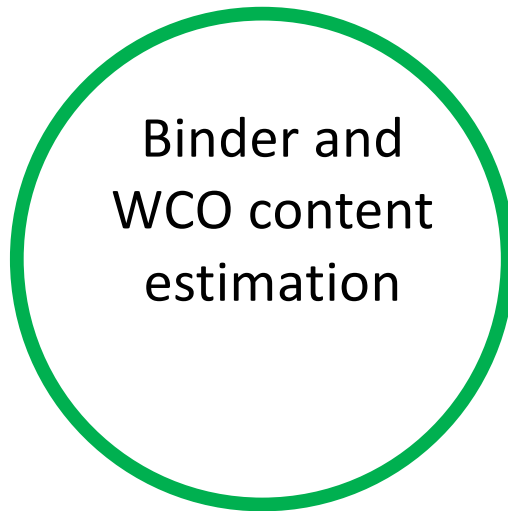


# Mix-design

## Properties of raw materials

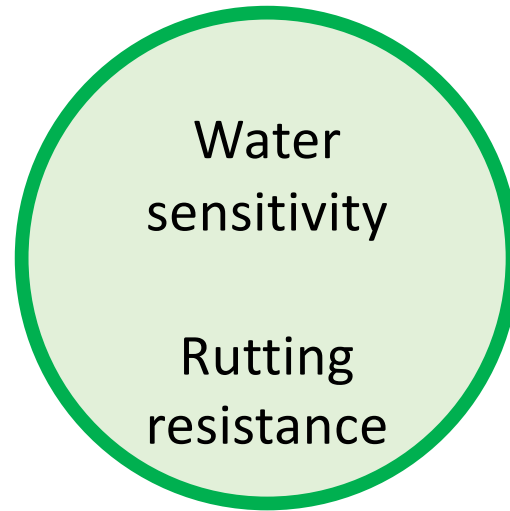


## Preliminary blends



Marshall test

## Verification



## Complementary performance tests



Ageing?  
Full scale field trials?



# Production of blends and specimens

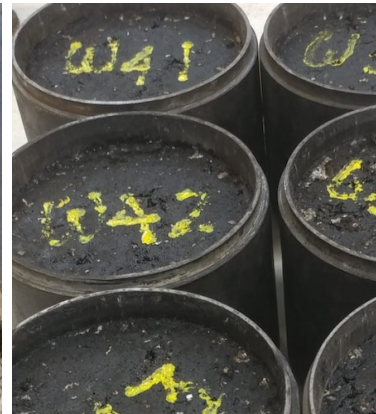
RAP  
disaggregation



Dosage

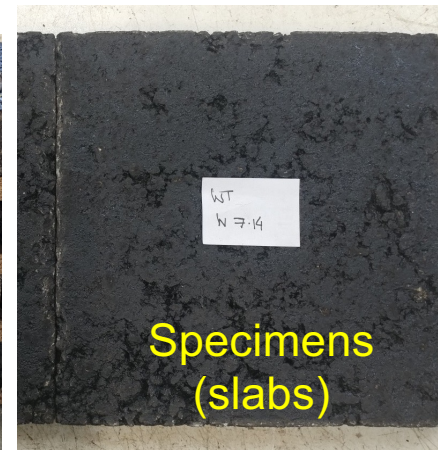
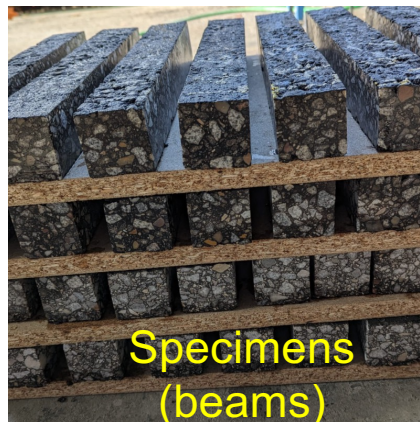
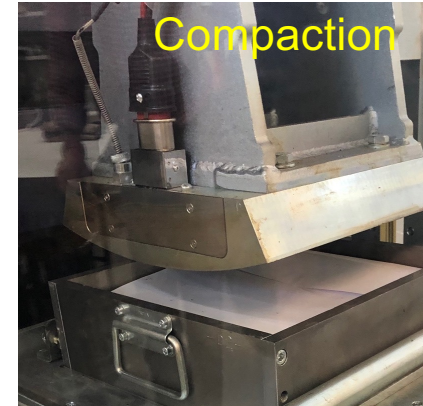
10%  
WCO by  
weight of  
binder

Mixing



Compaction

# Production of blends and specimens



# Asphalt mixtures' properties

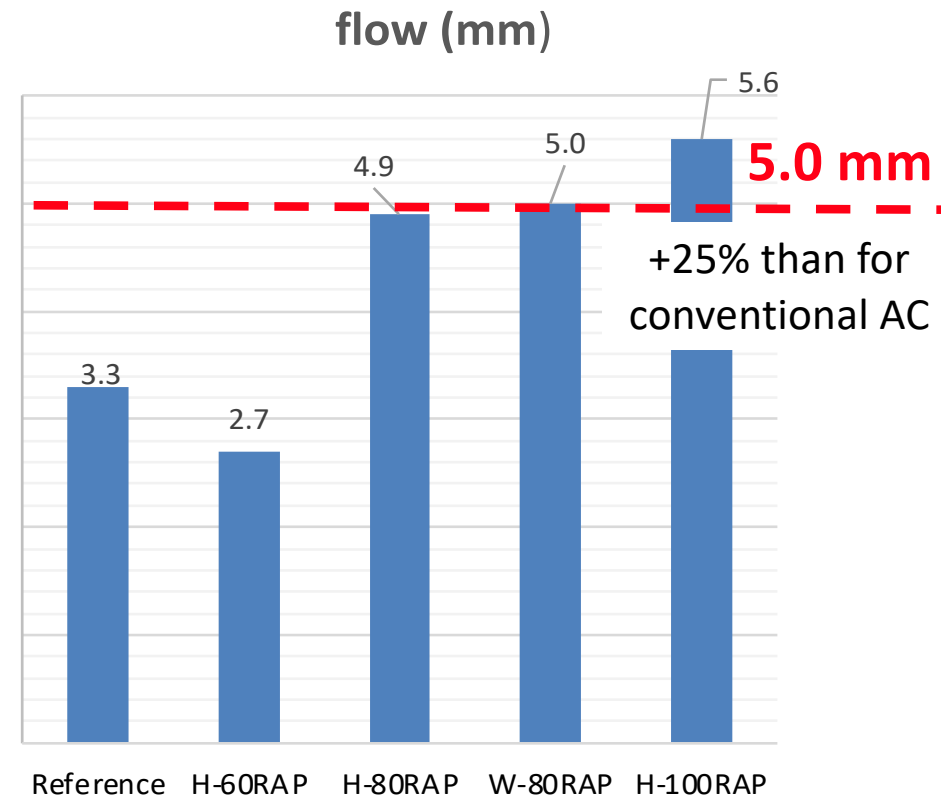
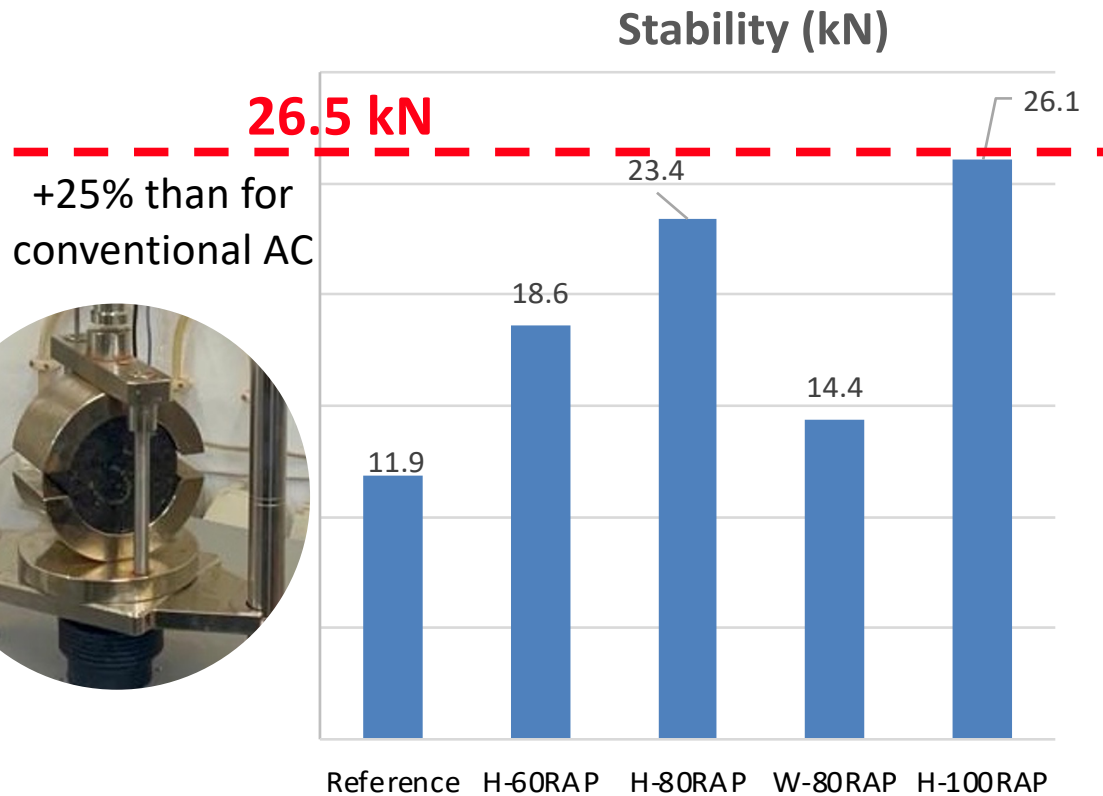
Marshall specimens



Marshall test @60°C



# Asphalt mixtures' properties



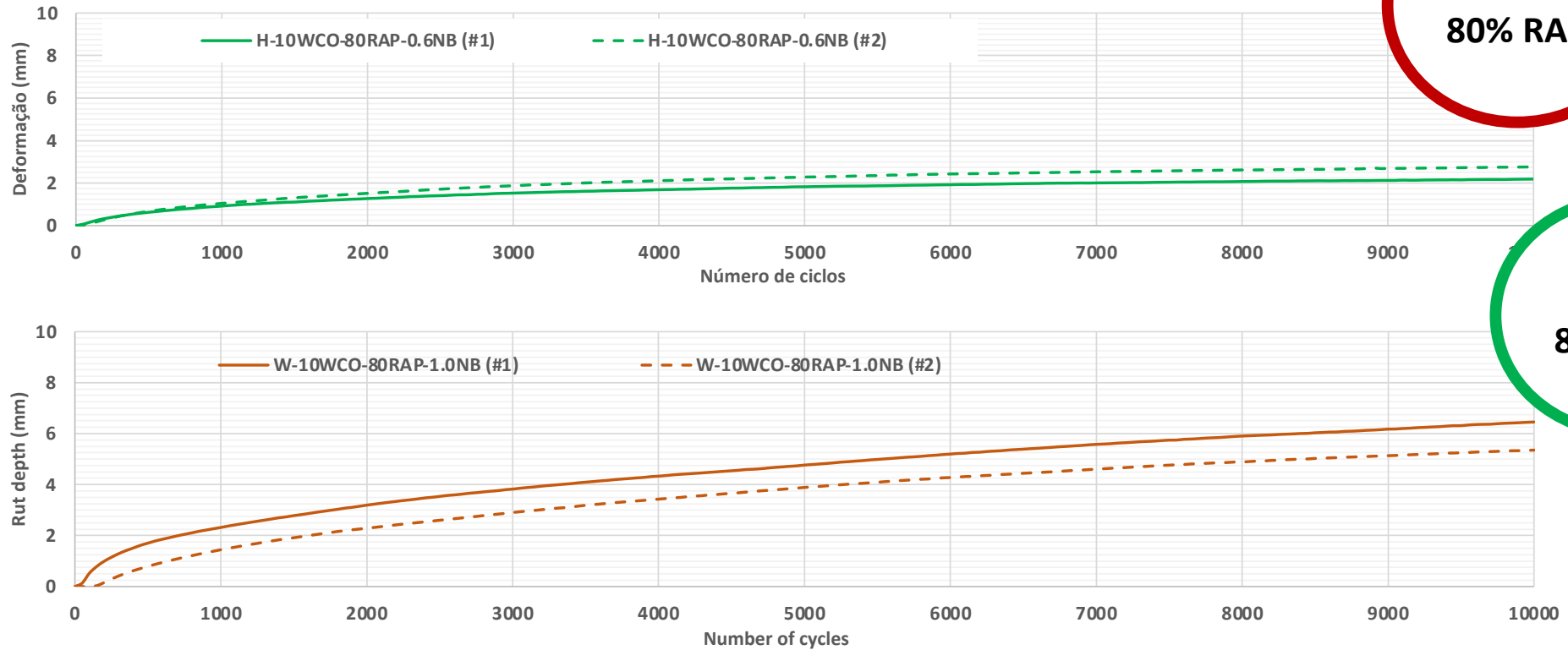
# Asphalt mixtures' properties

Wheel-tracking @ 50°C



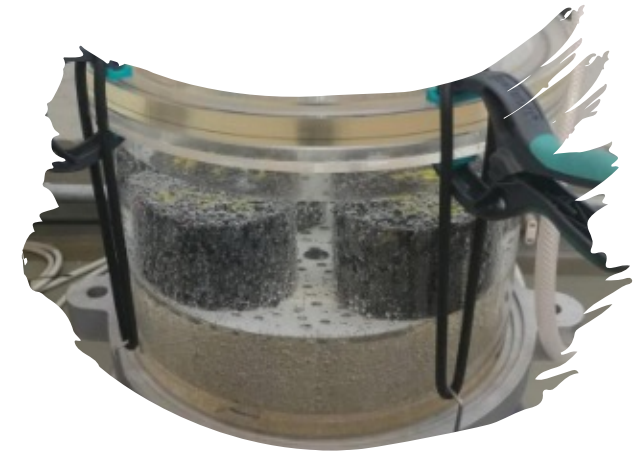
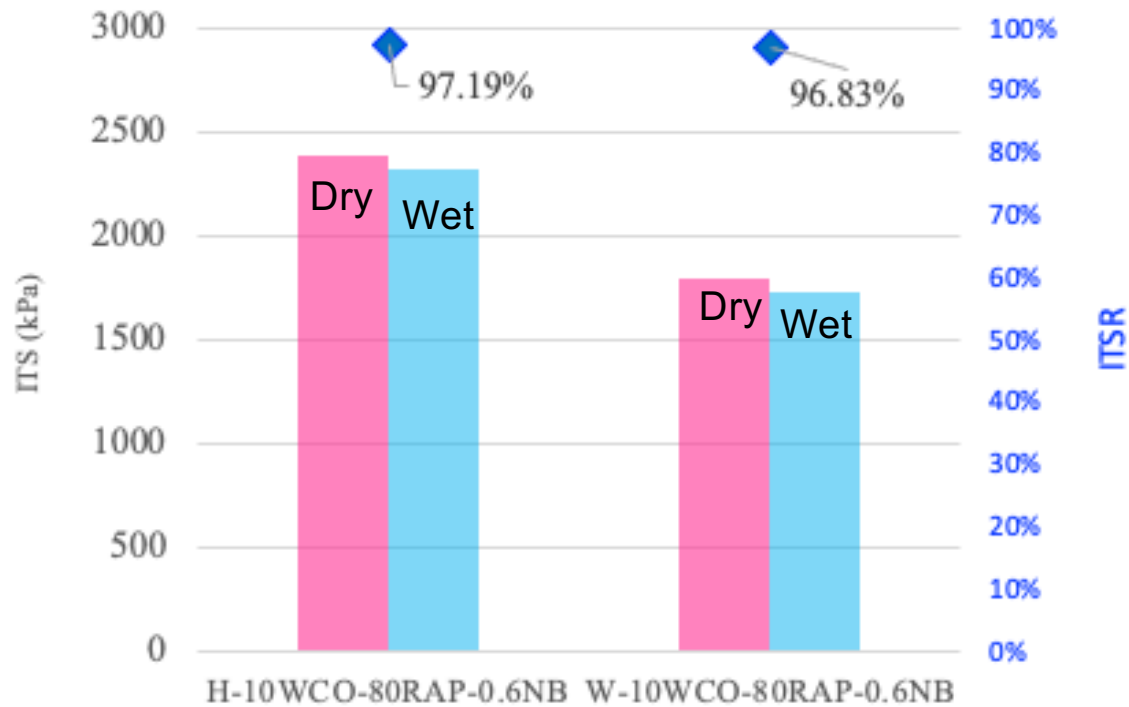
# Asphalt mixtures' properties

## Wheel-tracking @ 50°C



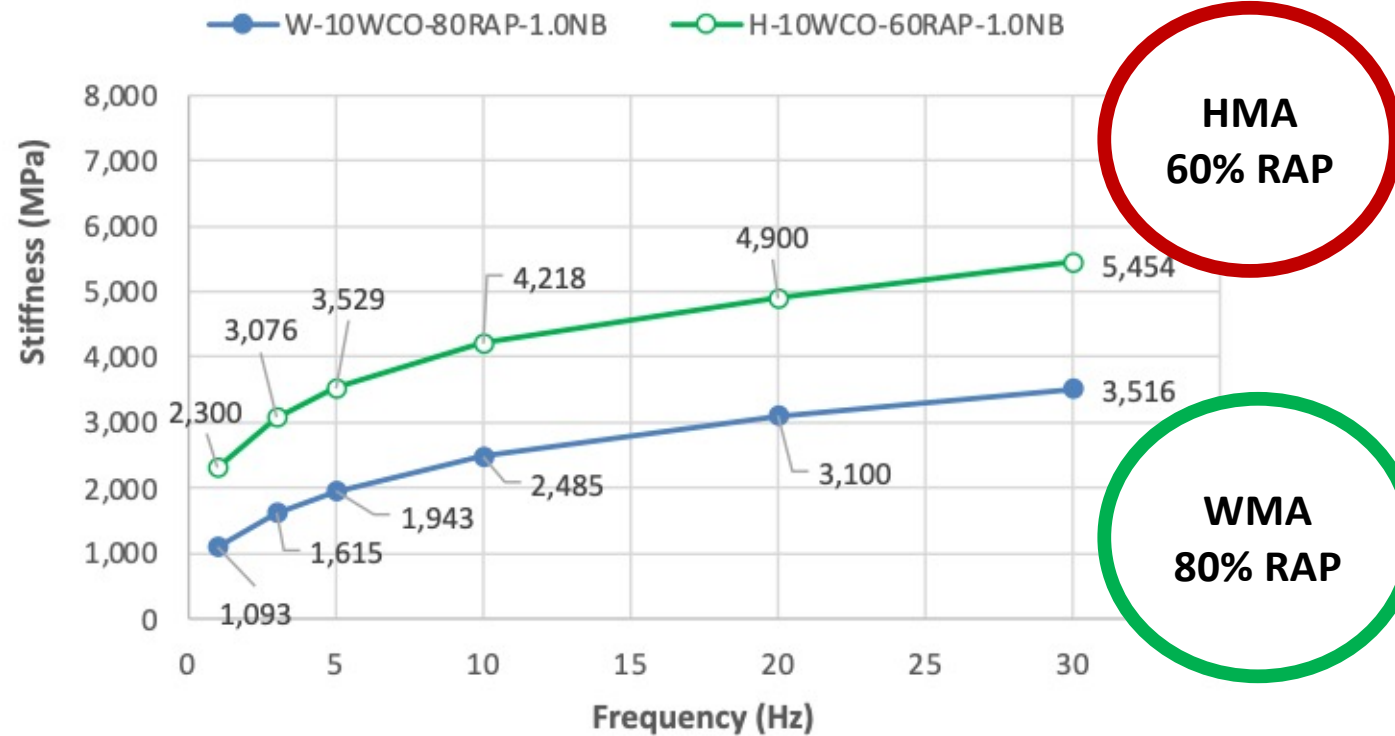
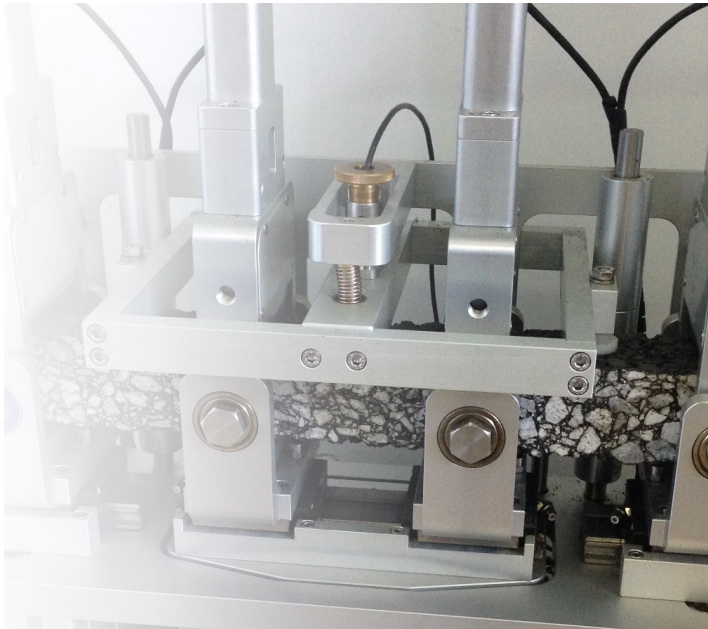
# Asphalt mixtures' properties

Water sensitivity @ 15°C (indirect tensile strength)



# Asphalt mixtures' properties

Stiffness @ 20°C





# Asphalt mixtures' properties

Resistance to fatigue  
cracking @ 20°C before  
and after ageing

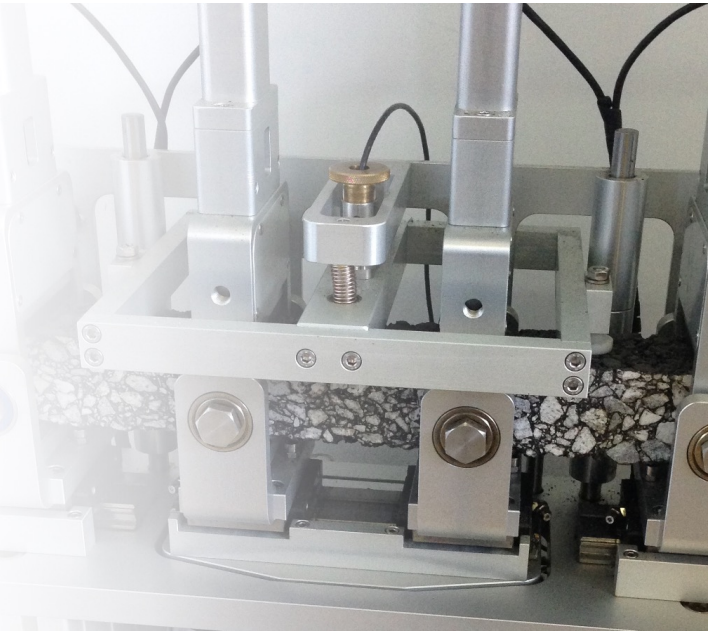
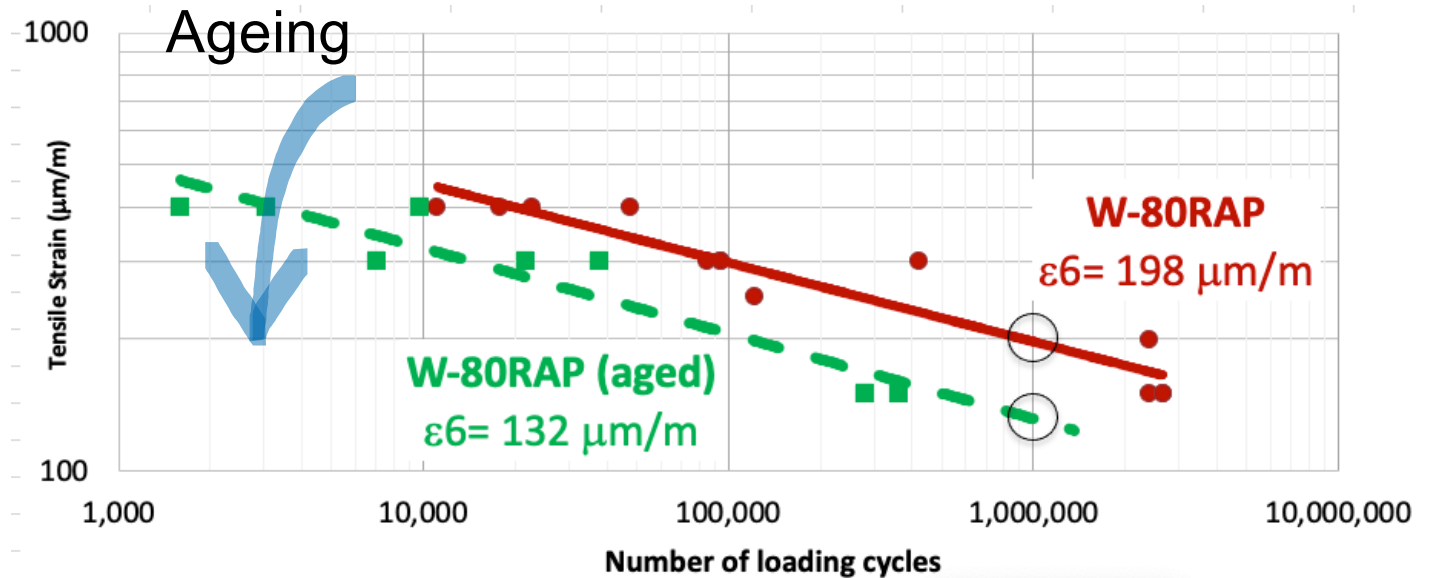
Simulates long-term ageing effect on  
compacted specimens (subjected to UVB  
radiation and dry/wet cycles)

[Source: Crucho *et al.* 2020]



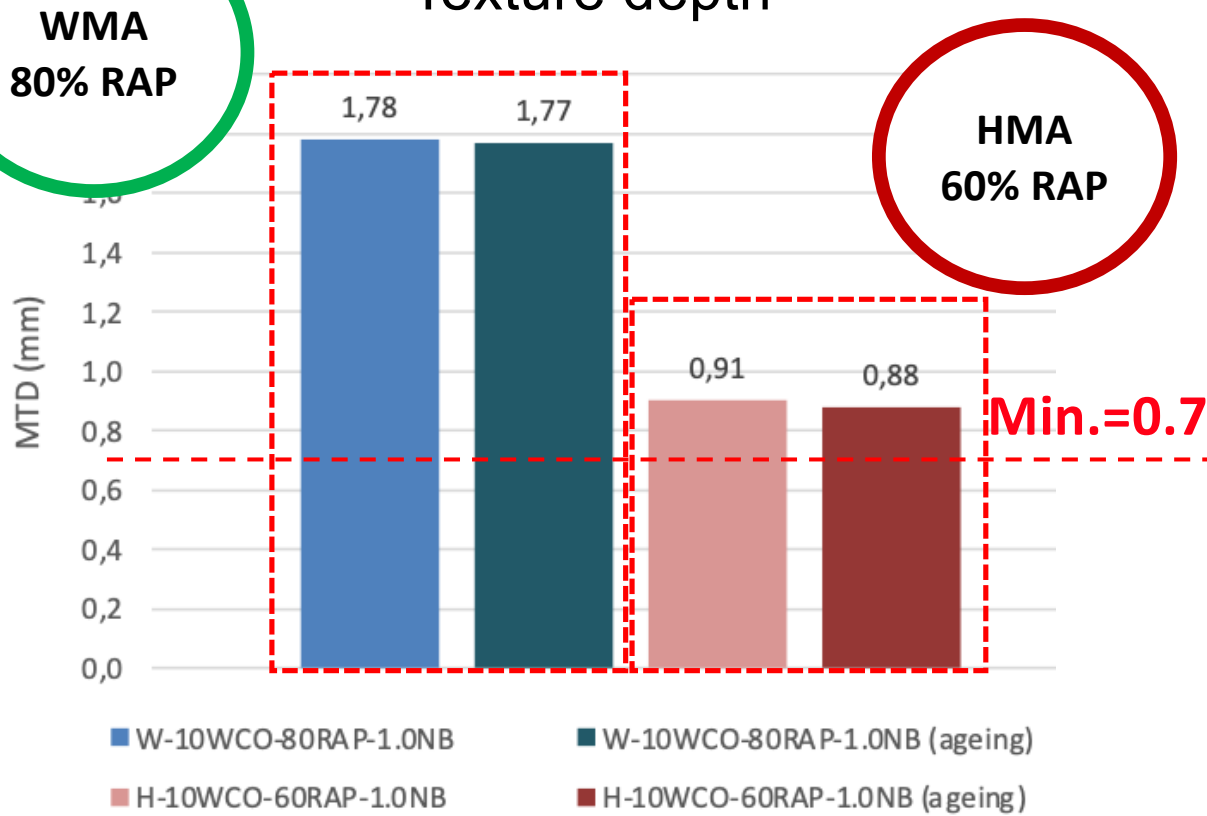
# Asphalt mixtures' properties

Fatigue resistance @ 20°C



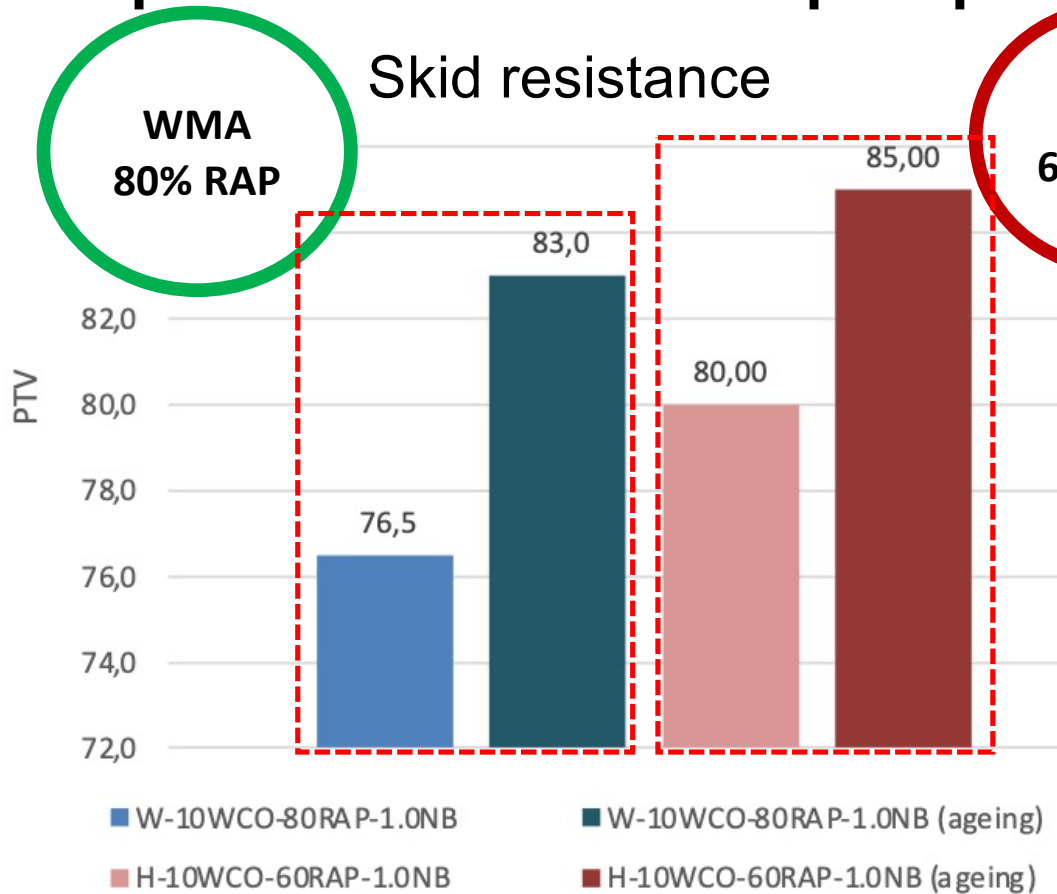
# Asphalt mixtures' properties

Texture depth



# Asphalt mixtures' properties

## Skid resistance



**Min.=60**

# Full scale prototypes

Evaluation of manufacturing conditions in a drum asphalt plant for warm-mix asphalt and hot-mix asphalt.



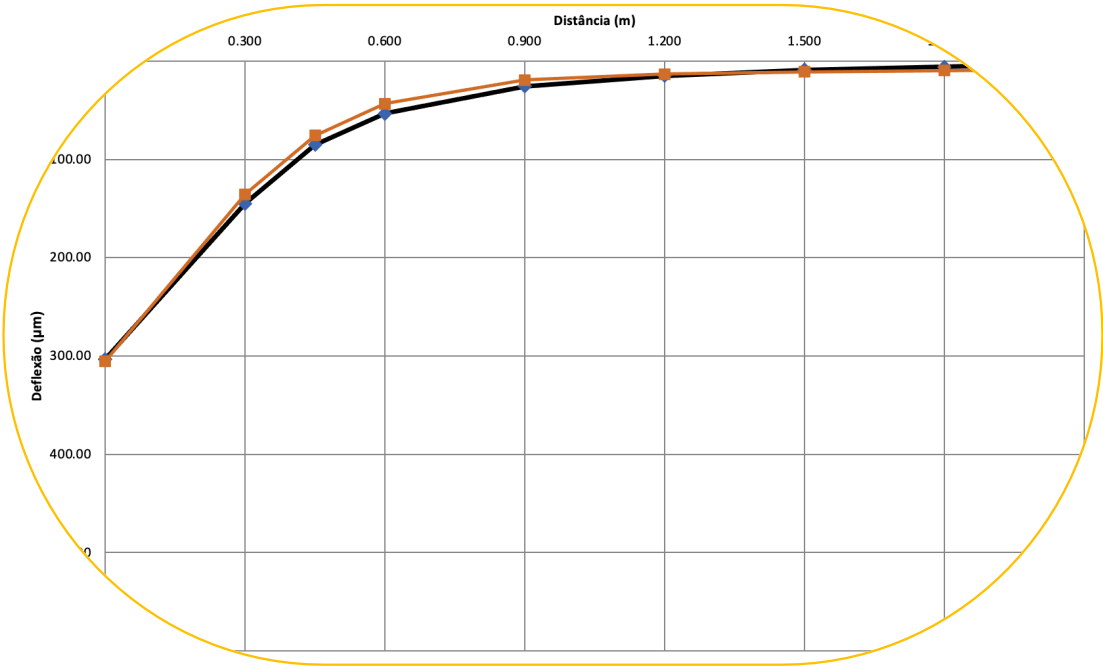
# Full scale prototypes

Evaluation of laydown and compaction conditions for warm-mix asphalt and hot-mix asphalt.



# Full scale prototypes

FWD tests to assess the layers' bearing capacity.



# Ongoing developments

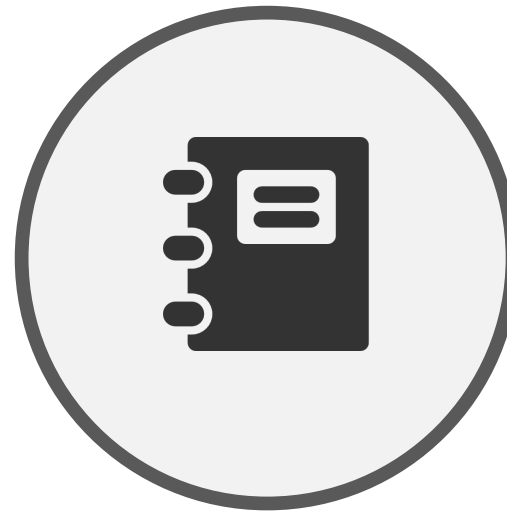
Life-cycle Analysis



Air emissions



Industrial licensing



Best practice  
guide





Iceland  
Liechtenstein  
Norway grants

be  
-ready  
RESilient roAD  
pavements for  
sustainability

# Recycling of RAP with Waste Cooking Oil as a rejuvenator in asphalt concrete

## Funding:

Lisb@20<sup>20</sup>

COMPETE  
2020

PORTUGAL  
2020

UNIÃO EUROPEIA  
Fundo Europeu  
de Desenvolvimento Regional



## Partners:



Thank you for your attention.

