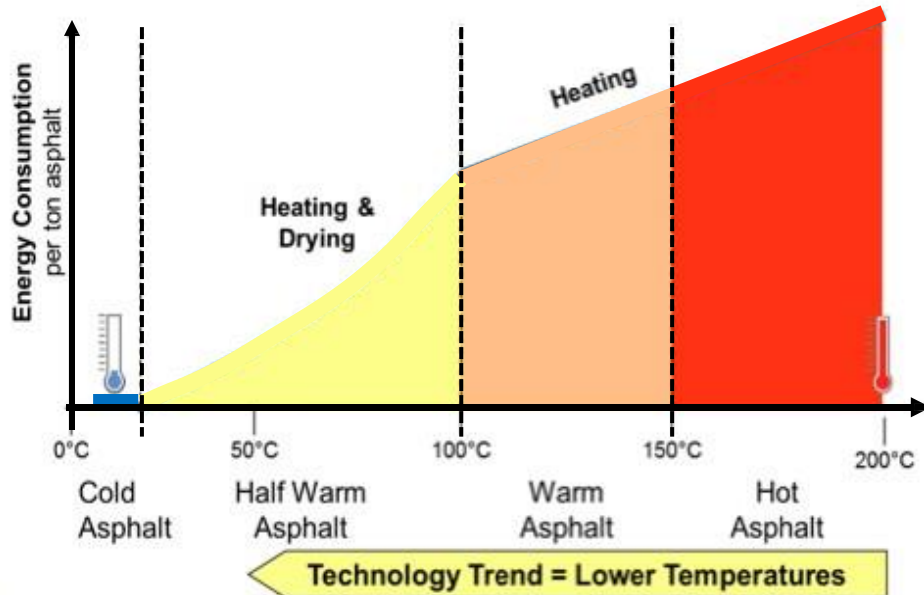


# OVERVIEW OVER TWO TECHNOLOGIES TO REDUCE EMISSIONS

*Eng. Lorenzo Sangalli*

# 1. WARM MIX ASPHALT (WMA)

# ASPHALT CONCRETE PRODUCTION METHODS



**HMA**  
160÷180°C

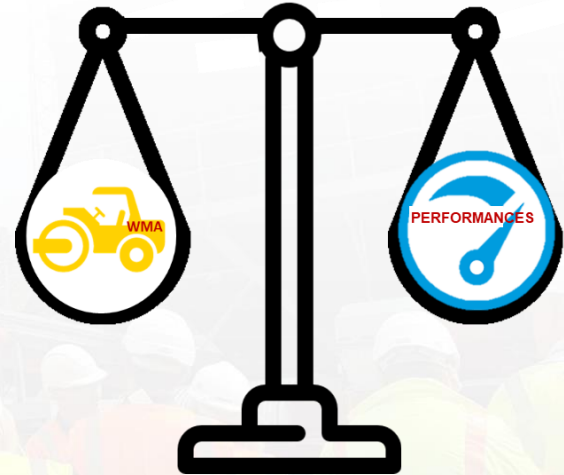


**WMA**  
100÷140°C



**CMA**  
 $T_{AMB}$

# ASPHALT CONCRETE PRODUCTION METHODS

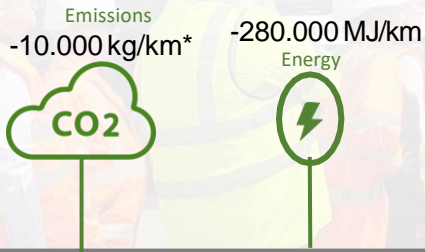


WMA technology has to keep the same performances of HMA asphalt concrete pavement

# WHAT WMA TECHNOLOGY ENABLES?

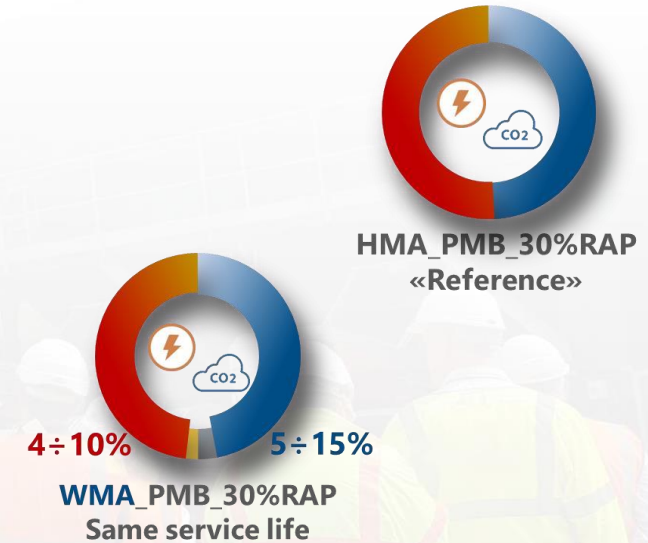
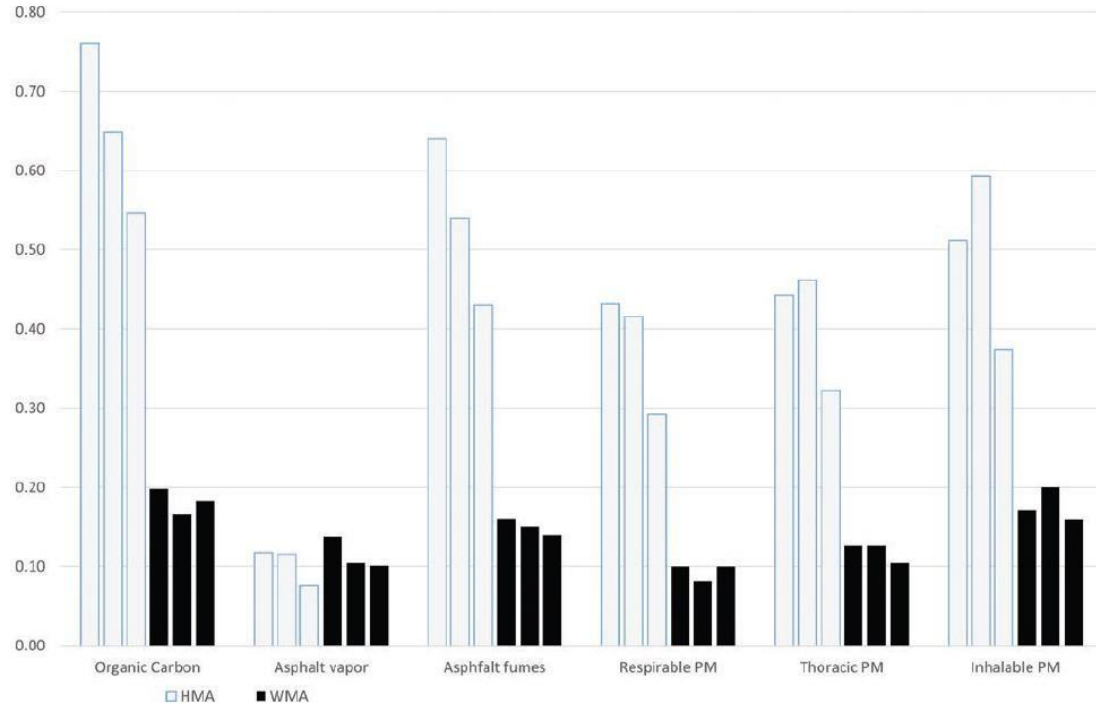
- Reducing fuel and energy consumption
- Reducing greenhouse gas emissions
- Safer working environment
- Improving the working air quality
- Allowing farther hauling distances
- Extending the workable period for asphalt projects
- Decreasing level of short-term aging of bitumen

This technology meets all  
aspects of  
**Sustainability!**



1 km x 10 m x 25 cm

## Individual measurements of air contaminants



Raymond, o. et. AL, (2021). Occupational Exposure during Asphalt Paving Comparison of Hot and Warm Mix Asphalt in Field Experiments. *Annals of Work Exposures and Health*, 2021, 1–12  
doi: [10.1093/annweh/wxaa129](https://doi.org/10.1093/annweh/wxaa129)

## Organic additives (e.g., waxes and fatty amides)

These additives are usually added directly to the mixer at the same time or shortly after the binder is added. It should not be added directly to the dry and hot aggregates. The post-mixing time after adding the viscosity-modifying additives in the mixer should be increased by at least 5-10 s.

## Chemical additives (e.g., surfactants)

An advantage of using chemical additives is that they usually do not cause any permanent rheological changes in the binder. Once the compaction is finished, there is no influence on the performance at high or low temperature. Only chemical additives can guarantee an adequate moisture susceptibility. Organic waxes and zeolite tend to reduce this property of WMA mixtures

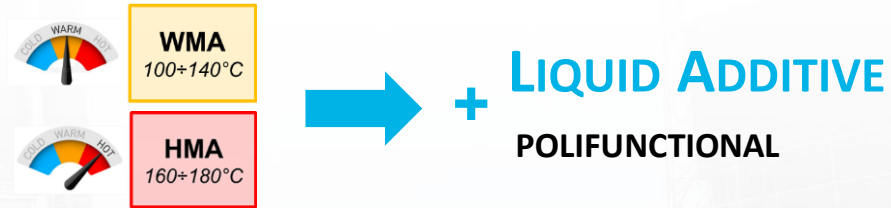
## Production-plant foaming techniques (e.g., foaming equipment)

The direct method of foaming is to inject a small and controlled amount of water into hot bitumen via a foaming nozzle. This results in the sudden evaporation of the water, which produces a large but temporary increase in the effective volume and surface area of the binder.

## Foaming additives (Hydrophilic minerals) (e.g., Zeolite)

Zeolite is a crystalline hydrated aluminium silicate that contains about 20 percent of crystalline water, which is released above 100°C. This release of water creates a controlled foaming effect

# WMA CHEMICAL ADDITIVES



Added in the bitumen, these polyfunctional additives (liquid but without water) allow to lower the production, laying and compaction temperatures of the asphalt concrete.

- ✓ THEY PROVIDE A CONTRIBUTION AS **ANTISTRIPPING AGENTS**
- ✓ THEY CAN BE ALSO USED FOR TRADITIONAL HMA PRODUCTION TO IMPROVE THE PERFORMANCE OF THE MIXTURE IN CASE OF ADVERSE WEATHER CONDITIONS.



# PRODUCTION PROCESS

## CHEMICAL ADDITIVE



BITUMEN



AGGREGATES



FILLER

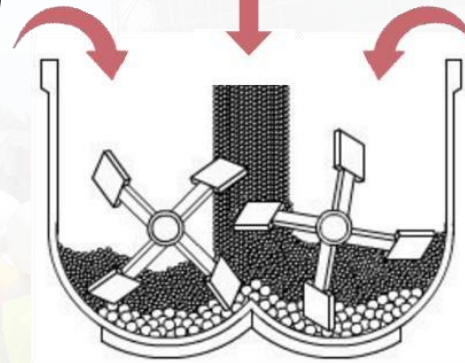


1. DURING  
PRODUCTION PROCESS

2. BITUMEN TANK  
(DEPENDENT ON  
ADDITIVE NATURE)

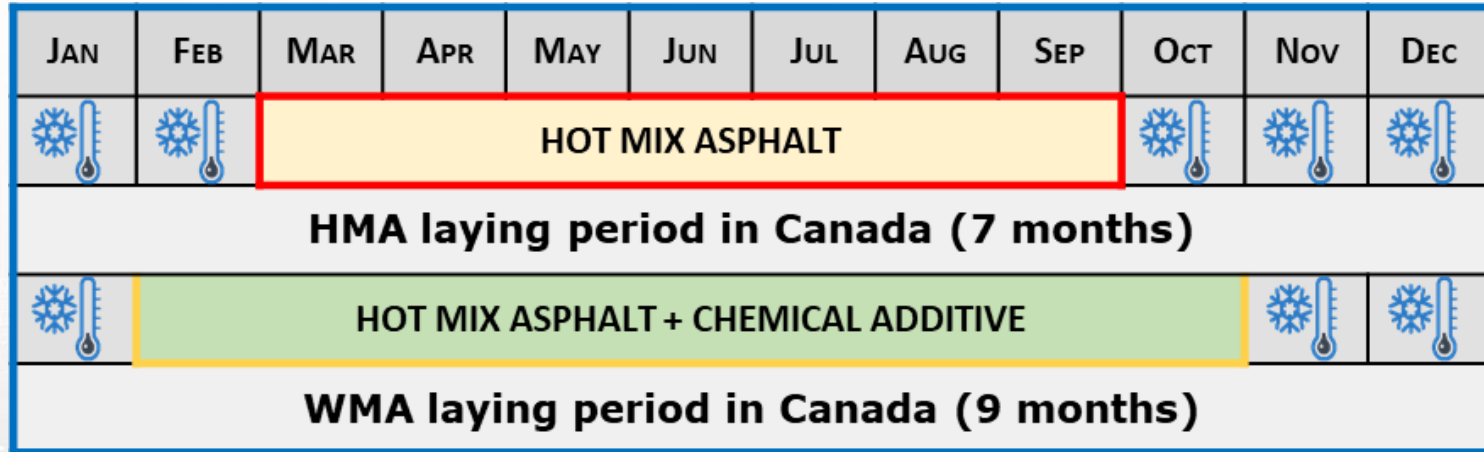


PLANT PRODUCTION



MIXER

# BENEFIT: WINTER PERIOD



Using chemical additives for WMA it is possible to extend the laying period during cold months

# BENEFIT: TIMING AND/OR LAYING DISTANCE

|                                    |                                |                               |
|------------------------------------|--------------------------------|-------------------------------|
| Traditional production at 180 °C → | <b>3 hour</b><br><b>150 km</b> | → Traditionl laying at 150 °C |
| Production WMA at 140 °C →         | <b>3 hour</b><br><b>150 km</b> | → Laying WMA at 110 °C        |
| Traditional production at 180 °C → | <b>7 hour</b><br><b>350 km</b> | → Laying WMA at 110 °C        |

## TRADITIONAL HMA



**3 ore**  
**150 km**



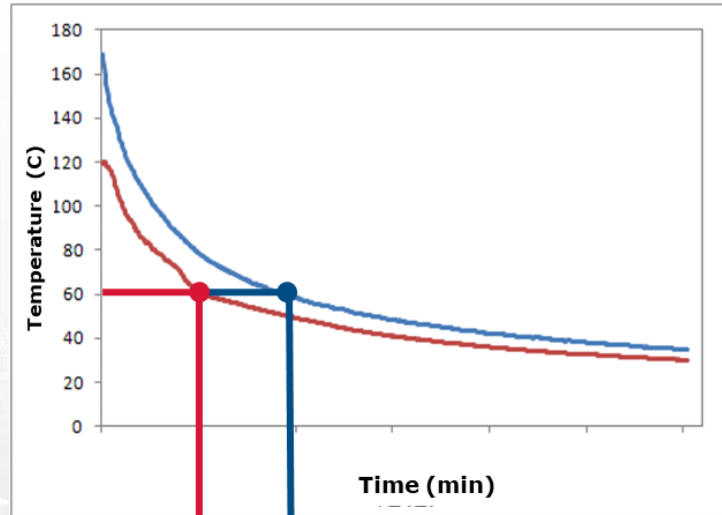
## HMA + WMA ADDITIVE

**7 ore**  
**350 km**



\* Gradient = - 10° C/hour, ambient temperature 20°C and transport speed 50 km/h

# BENEFIT: OPENING TO TRAFFIC



**WMA Pavement**  
**5 ore 20 min**

**HMA Pavement**  
**7 ore 30 min**

**FASTER OPENING**



**LOWER INDIRECT COSTS**

**FUNDAMENTAL FOR ROAD TIMINGS**

## **2. HIGH PERCENTAGE OF RECLAIMED ASPHALT WITH REJUVENATORS**




# RECLAIMED ASPHALT (RA)

RECLAIMED ASPHALT IS THE RESULTING MATERIAL DERIVING FROM THE DEMOLITION OF OLD PAVEMENTS (MILLED) WHICH, THROUGH THE TRANSFORMATION INTO “END OF WASTE”, CEASES TO BE CONSIDERED AS WASTE.



HAVING HIGH PHYSICAL-MECHANICAL CHARACTERISTICS, RA IS TOTALLY REUSABLE IN ROAD CONSTRUCTION, ESPECIALLY IN NEW BITUMINOUS MIXTURES, IF PROPERLY MANAGED.

# TREATMENT OF RA

| PHASE 1   | PHASE 2   | PHASE 3  | PHASE 4   | PHASE 5   | PHASE 6                           |
|---|---|--|---|---|-----------------------------------|
| Demolition of the pavement  | Initial check   | Treatment for crushing and / or screening  | Reclaimed Asphalt (RA)  | Storage and management of RA stockpiles                       | Reuse or Recycling of RA          |
| Separation of the superficial layers from the deeper ones                         | Presence of foreign materials, dimensions of the elements and environmental compatibility | Chemical and dimensional control of the elements and mixing if deriving from different sources | Transformation from waste to EOW product  | Storage and management of stockpiles according to the sources | Mixtures produced hot and/or cold |
|  |          |             |  |   |                                   |

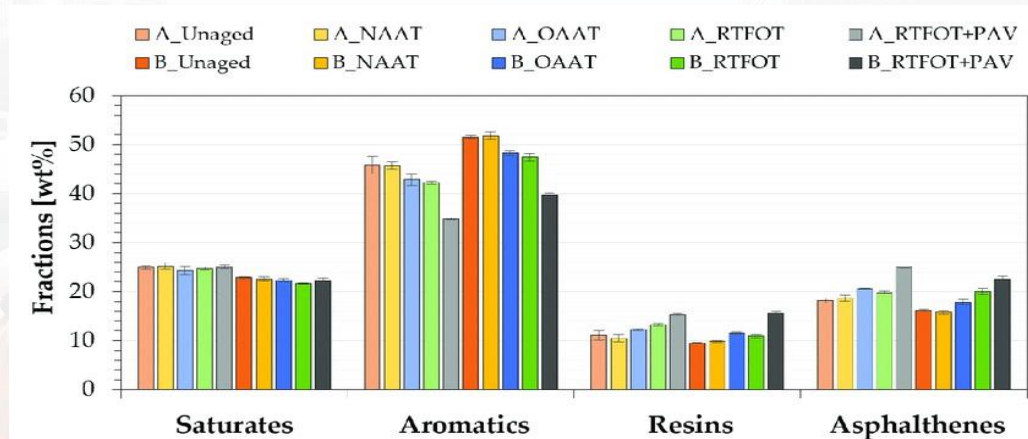
**MAXIMUM SAVINGS AND FINAL PERFORMANCE OF THE NEW BITUMINOUS MIXTURES**



## AGING

The bitumen undergoes a chemical transformation both during the storage and production phases of the asphalt concrete, and during the use of the pavement.

The chemical process involves the oxidation of the bitumen, the loss of volatile parts and the deterioration of the performances.



Effect of Thermal and Oxidative Aging on Asphalt Binders Rheology and Chemical Composition

(I. Camargo, J.Mirwald; B. Hofko; H. Grothe)

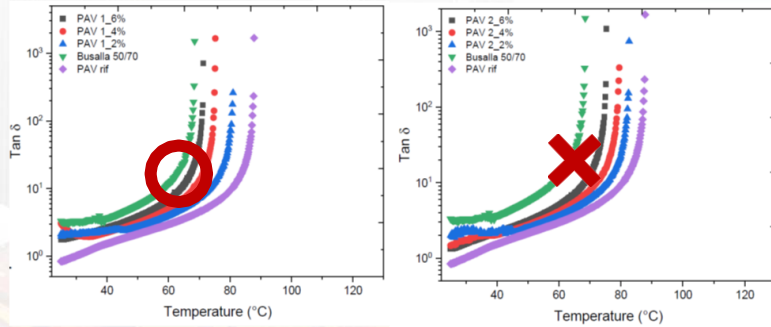




## REJUVENATION

The rejuvenation of oxidized bitumen consists in the use of special products which, during the use of the RA, allow to restore its chemical composition, restoring it, partially or totally, to its initial state.

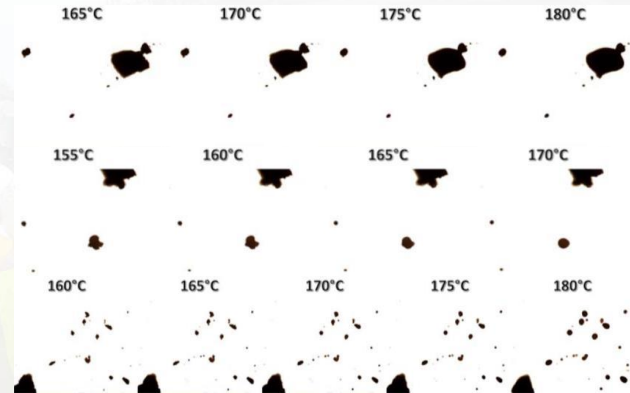
**Dynamic Shear Rheometer (DSR) test**



**Rejuvenator**

**Flux Oil**

**Asphaltene melting point**



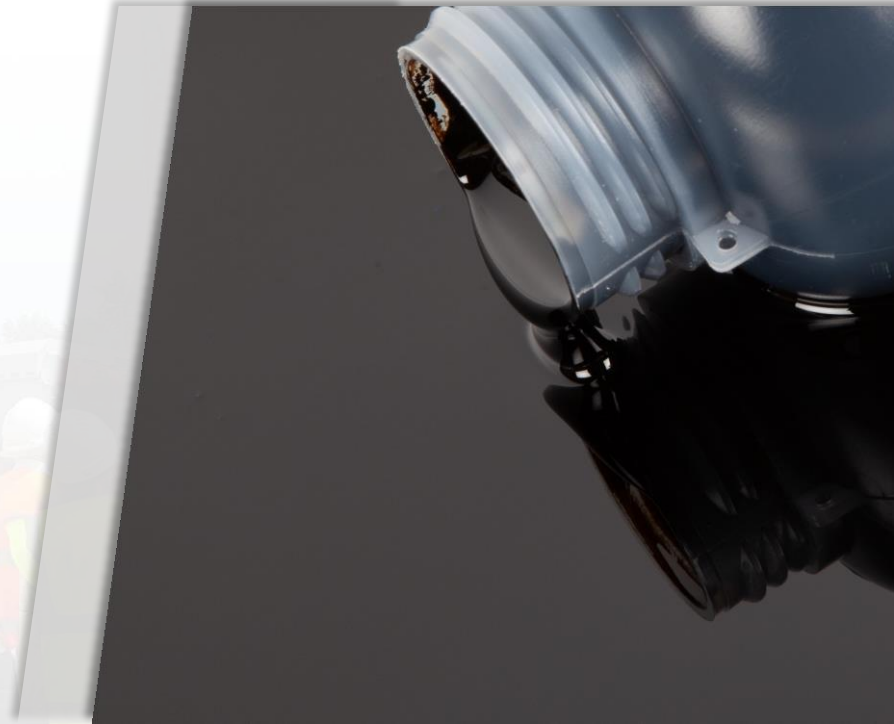
# REJUVENATOR VS FLUX OIL

## FLUX OIL

The flux only improves the workability of the mixture containing RA, to facilitate its construction.

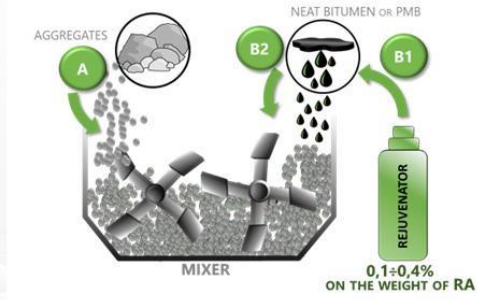
## REJUVENATOR

The rejuvenator partially or totally reintegrates the chemical components of the aged bitumen contained in the RA, giving the mixture adequate workability for construction and restoring the performance of the bitumen, ensuring new service life.

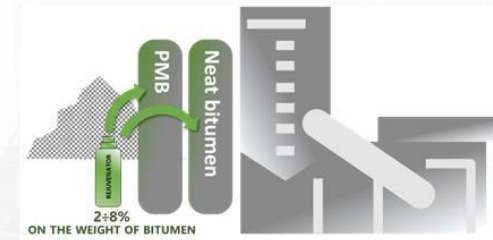


# REJUVENATOR - DOSAGE

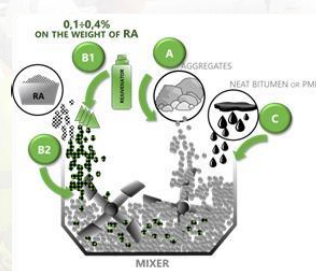
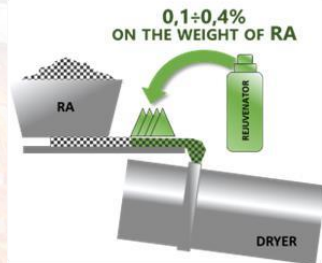
1. Insertion in the bitumen during the production cycle  
in both batch plant and drum-mix plant, with quantity based on RA



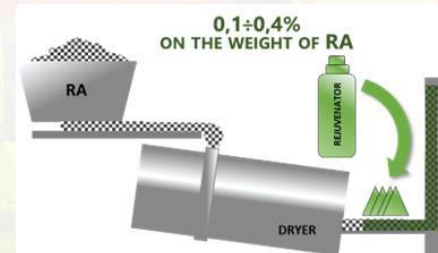
2. Insertion in the bitumen tanks  
early decay of regenerating properties due to thermosensitivity  
and fixed content regardless of the percentage of RA used



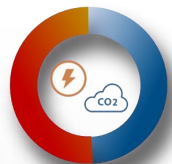
3. Spraying on the RA  
before entering the dryer drum (hot process) or directly into the mixer  
(cold process)



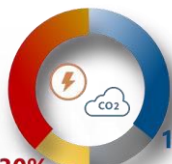
4. Spraying of RA and aggregates  
after passing through the dryer drum and before the bucket  
elevator (discontinuous system only)



# SUSTAINABLE PAVEMENTS - RECYCLING



HMA\_PMB\_30%RAP  
«Reference»



15÷30%  
HMA\_PMB\_70%RAP  
Same service life

## Hot recycling of old pavements

The rejuvenation of the materials deriving from the demolition of old pavements allows to save resources and reduces CO<sub>2</sub>eq emissions, ensuring equal service life.



Asphalt pavement with 40% of RA  
1 km x 10 m x 25 cm



-35.000 kg/km

for the production only, with respect to the materials of first use



-885.000 MJ/km



-104 t



-2.240 t

# CASE HISTORIES

# 1. IRELAND

- **Location:** N80 Ballymacken; Ireland
- **Construction date:** 2021
- **Type of road:** Regional road
- **Type of Asphalt:** AC 20; 25% RA
- **WMA dosage:** 0.4% on bitumen weight
- **Rejuvenator dosage:** 0.2% on RA weight
- **Paving Bitumen:** PEN 70/100
- **Production Temperature:** ave. 130°C
- **Compaction Temperature:** ave. 100°C



# 1. IRELAND

| Mix Description   | AC20 Ref. | AC20 WMA+Rej.   |
|---|-----------|-----------------|
| <i>Reclaimed Asphalt</i>                                  | Yes       | Yes             |
| <i>Additive</i>   | No        | Yes             |
| <i>Production Temperature</i>                             | 170°C     | 130°C           |
| <i>Air voids – Cores [%]</i>                              | 2,5       | 1,9             |
| <i>ITSR @ 15°C [%]</i>                                    | 91,9      | 95,6            |
| <i>WTS<sub>AIR</sub> @ 45°C [mm/1000cycles]</i>           | 0,03      | 0,03            |
| <i>PRD @ 45°C_10000 cycles [%]</i>                        | 1,66      | 1,30            |
| <i>Stiffness @ 20°C</i>                                   | 4767      | 2701            |
| <i>CO<sub>2</sub> equivalent (kg/hr) – Plant emission</i> | 2584,7    | 2339,8 (- 9,5%) |

## 2. IRELAND

- **Location:** Meath, Ireland
- **Construction date:** 2022
- **Type of road:** Regional Road
- **Type of Asphalt:** AC 20; 40% RA
- **WMA+Rej. dosage:** 0.13% on RA weight
- **Paving Bitumen:** PEN 70/100
- **Production Temperature:** ave. 150°C
- **Compaction Temperature:** ave. 130°C





## 3. GERMANY

- **Location:** Tutow; Germany
- **Construction date:** 2021
- **Type of road:** Link Road
- **Type of Asphalt:** AC 22; 50-60% RA  
AC 8; 45% RA
- **WMA dosage:** 0.5% on bitumen weight
- **Paving Bitumen:** PEN 50/70
- **Production Temperature:** ave. 130°C
- **Compaction Temperature:** ave. 100°C



# 3. GERMANY

| Station [km]                            | 0 + 025  | 0 + 150 |      |      |                                   |      |
|---|--|---------|------|------|-----------------------------------|------|
|   |  | 1A      | 1B   | 1C   | 1D                                | 2A   |
|   | Verdichtung erfolgte konventionell - erst statisch, dann mit Vibration |         |      |      | Verdichtung erfolgte nur statisch |      |
| BK-Nr.                                  | 1A   | 1B      | 1C   | 1D   | 2A                                | 2B   |
|   | Soll*)   |         |      |      |                                   |      |
| <b>1. Asphaltdeckschicht (AC 8 DN)</b>  |  |         |      |      |                                   |      |
| <i>Mischgutprobe</i>                    |  |         |      |      |                                   |      |
| 1.1 Einbaudicke [cm]                    | 3,5  | 3,5     | 3,4  | 3,5  | 3,6                               | 3,4  |
| 1.2 Hohlraumgehalt [Vol.-%] ≤ 5,5       | 2,4  |         |      |      | 3,0                               |      |
| 1.3 Verdichtungsgrad [%] ≥ 98,0         | 98,6   |         |      |      | 98,0                              |      |
| 1.4 Raumdichte (BK) [g/cm³]             | 2,356  |         |      |      | 2,343                             |      |
| 1.5 Rohdichte (BK) [g/cm³]              | 2,415  |         |      |      | 2,415                             |      |
| 1.6 Raumdichte (MPK) [g/cm³]            | 2,390  |         |      |      | 2,391                             |      |
| 1.7 Schichtenverbund [kN] ≥ 12,0        | 19,7   |         |      |      |                                   |      |
| <b>2. Asphalttragschicht (AC 22 TS)</b> |  |         |      |      |                                   |      |
| <i>Mischgutprobe</i>                    |  |         |      |      |                                   |      |
| 2.1 Einbaudicke [cm]                    | 7,2  | 7,2     | 7,1  | 7,0  | 8,1                               | 7,9  |
| 2.2 Verdichtungsgrad [%] ≥ 98,0         | 99,7   |         |      |      | 97,0                              |      |
| 2.3 Raumdichte (BK) [g/cm³]             | 2,352  |         |      |      | 2,263                             |      |
| 2.4 Raumdichte (MPK) [g/cm³]            | 2,358  |         |      |      | 2,333                             |      |
| <b>3. Gesamtdicke des BK</b>            | 10,7   | 10,7    | 10,5 | 10,5 | 11,7                              | 11,3 |

Static + vibrated compaction

Static compaction



## 4. ITALY

- **Location:** Rome; Italy
- **Construction date:** 2019
- **Type of road:** Taxiway
- **Type of Asphalt:** AC 32; 30% RA  
AC 25; 25% RA  
AC 16; 20% RA
- **WMA+Rej. dosage :** 0.15% on RA weight
- **Paving Bitumen:** PEN 50/70
- **Production Temperature:** ave. 180°C
- **Compaction Temperature:** ave. 110°C (6h delivery time)



### 7.3 ADDITIVI RIGENERANTI/FLUIDIFICANTI

Gli additivi rigeneranti/fluidificanti sono composti chimici da utilizzare sempre nelle lavorazioni in cui si reimpiegano materiali fresati nella produzione di conglomerati bituminosi a caldo.

Essi devono avere caratteristiche tali da modificare e migliorare le proprietà di adesione, suscettibilità termica, coesione, viscosità e resistenza all'invecchiamento del legante totale (vecchio + nuovo).

Il dosaggio sarà indicativamente dello 0,2%-0,8% in peso rispetto al legante totale, secondo indicazioni della DL ed in accordo con i Laboratori accreditati o con il CSS; a seconda dell'impiego l'additivo può essere disperso nell'acqua o nel legante di aggiunta (bitume od emulsione). Può anche essere aggiunto nel fresato, durante la fresatura, nel caso di impiego diretto.

I prodotti devono essere approvati dalla DL sulla base di specifiche prove eseguite dai Laboratori accreditati valutandone il dosaggio e l'efficacia, eventualmente con metodologie concordate e/o definite da CSS per la relativa accettazione.

Inoltre i prodotti devono essere accompagnati dalle schede tecniche che ne indicano caratteristiche, sicurezza e modalità di impiego, che potranno essere verificati anche con appositi test di cantiere.

Per la verifica delle effettive quantità impiegate, vanno fornite in copia alla DL le bolle di consegna.

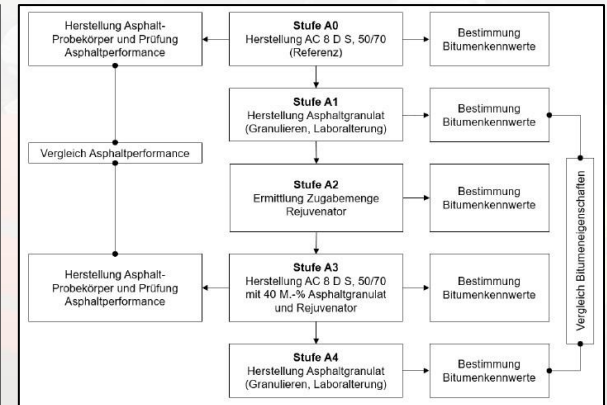
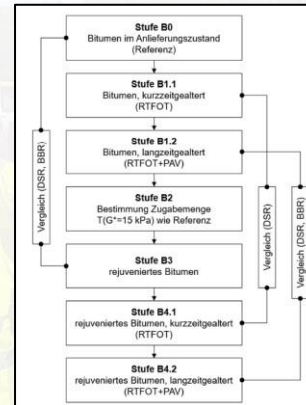
In alternativa agli additivi rigeneranti e/o flussanti, allo stesso scopo possono essere utilizzati bitumi appositamente formulati specifici per il riciclaggio del conglomerato.

## Italy:

- Nowadays average use of 20-40% RA;
- From 2024 CAM with minimum of 50% RA and reduction in emissions.

## Germany:

- Nowadays average use of 30-35% RA;
- From 2025 production 100% WMA.





***Go raibh mile maith agat!***