# Polymer Modified Asphalt: Innovative Technology for High Durable Road Pavements

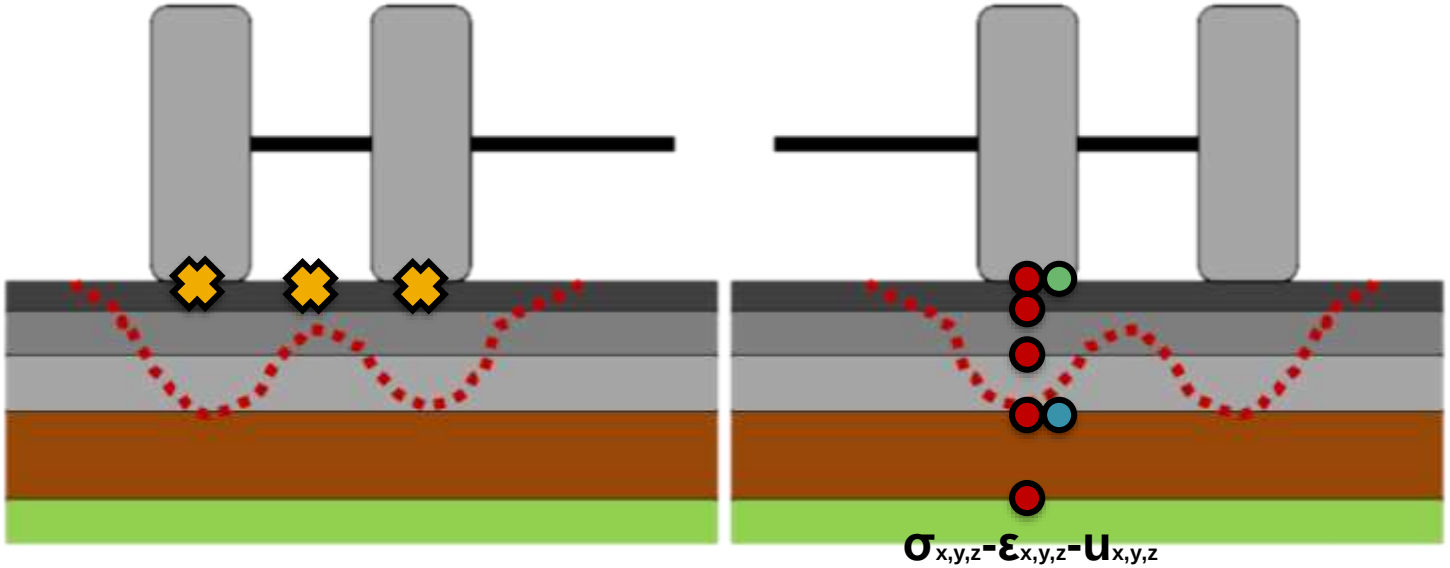
# Polimerom modificirani asfalt: Inovativna tehnologija za jako trajne cestovne kolnike

Luca Baccellieri, Interchimica

# Pavement-Load

There is a tight connection between

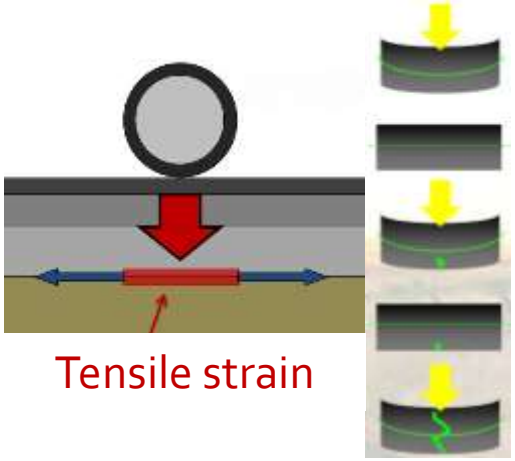
## LOAD – MECHANICAL PERFORMANCE – LIFE TIME



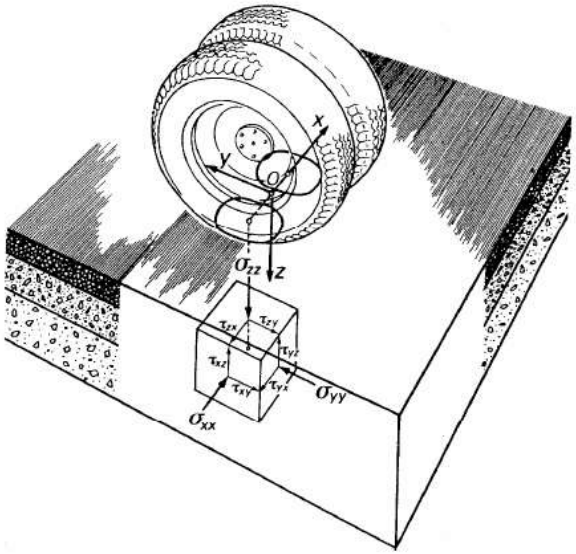

- **Static and dynamic load;**
- In function of the **load and temperature** is possible to check the tensile inside the pavement;
- **Green spot -> Displacement -> Rutting phenomenon**
- **Blue spot -> Tensile Strain (εt) ->Fatigue phenomenon**

# Pavement-Load-Damage

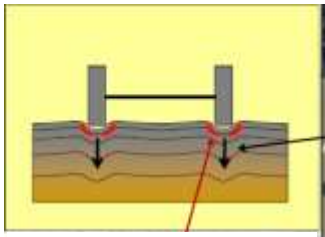
## FATIGUE CRACKING



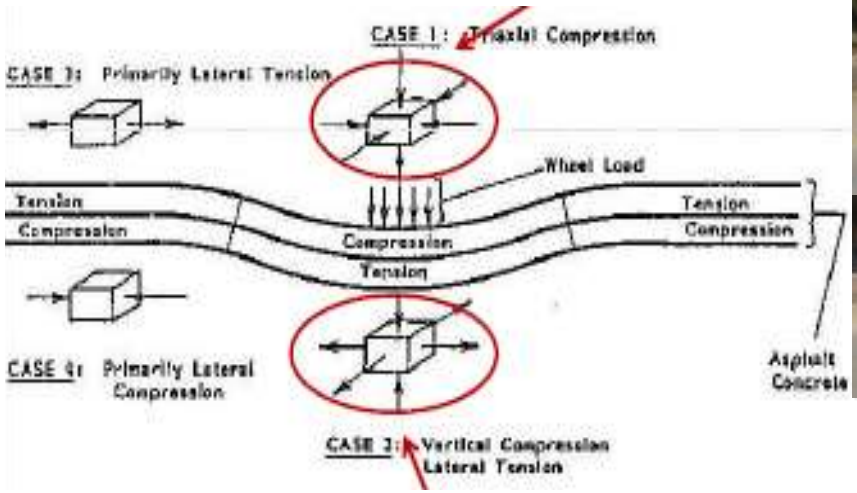
Tensile strain




## RUTTING



Rutting


## BASE COURSE

## WEARING COURSE

# PMA Technologies

Compound of polymers and fibers

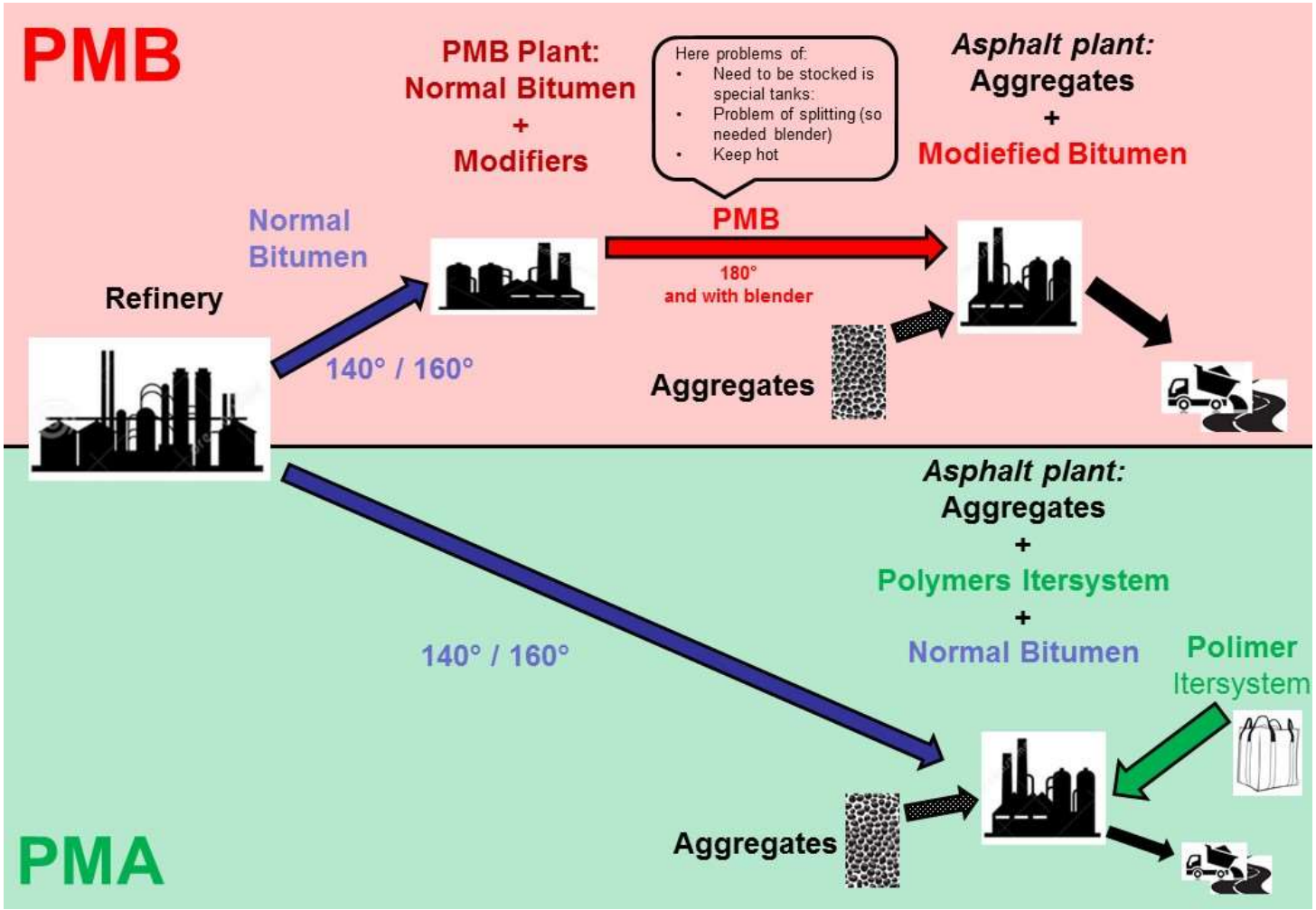
Compound of thermoplastic copolymers

Iterchimica ITERSYSTEM.mp4

**ADDED DIRECTLY INTO THE MIXER**

**Possibility to adjust the modification degree of the mix design, changing the modifiers dosage**

# COMPARISON BETWEEN PMB AND PMA TECHNOLOGIES



# PMA Technologies

*INNOVATIVE SOLUTION*

**SUPERPLAST**

***ADDED IN THE MIXER***

**Possibility to choose the modifier and its relative quantities**

SUPERPLAST IS A **POLYMERIC COMPOUND** OF SELECTED THERMOPLASTIC POLYMERS MADE OF FLEXIBLE GRANULES WHICH, WHEN ADDED TO THE ASPHALT MIX, **INCREASES THE PAVEMENT STRENGTH, THE FATIGUE RESISTANCE**

# PMA Technologies

**PPS (Polyfunctional Polymeric System)**

- PLASTOMERS or ELASTOMERS
- FIBERS
- OTHER ADDITIVES

- Combination of the benefits;
- Increase of the resilience;
- Higher resistances for high thermal fluctuations;
- Intervention on more physical-mechanical characteristics.

**HOT WEATHER**

**COLD WEATHER**

**THERMAL FLUCTUATIONS**

# PMA Applications

**The main application are:**

- High Perfomance CA;
- SMA (Stone Mastic Asphalt)
- High Modulus Asphalt Layers (HiMA);
- Rut and crack resistant top layers for durable low maintenance pavements;
- Thin layer asphalt of various thicknesses;
- Airport runway surfacing for high performance and cost-effective maintenance

# PMA in Plant

0,3÷0,6%
on mix

**PMA**

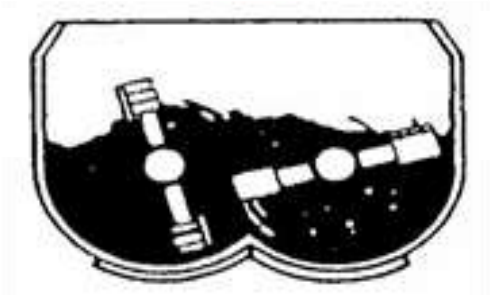
Polymers at
room temperature

②

4÷8%
on bitumen weight

Aggregates at
180°C

①



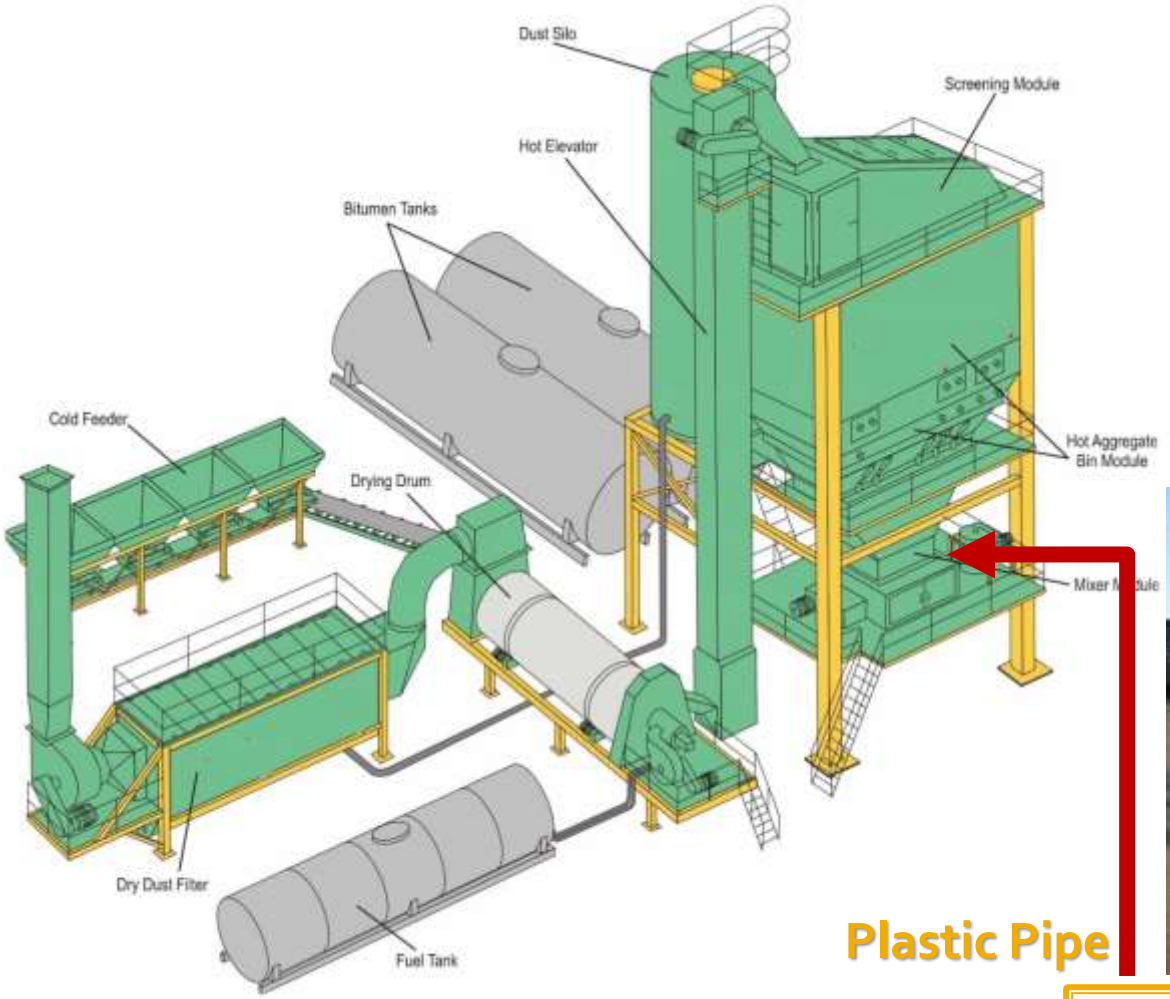
Bitumen at
160°C

③

**Mixer**

**Same equipments used in the traditional mixes**

# PMA in Plant




**PRODUCT**

**Big Bags**


**Plastic Pipe**

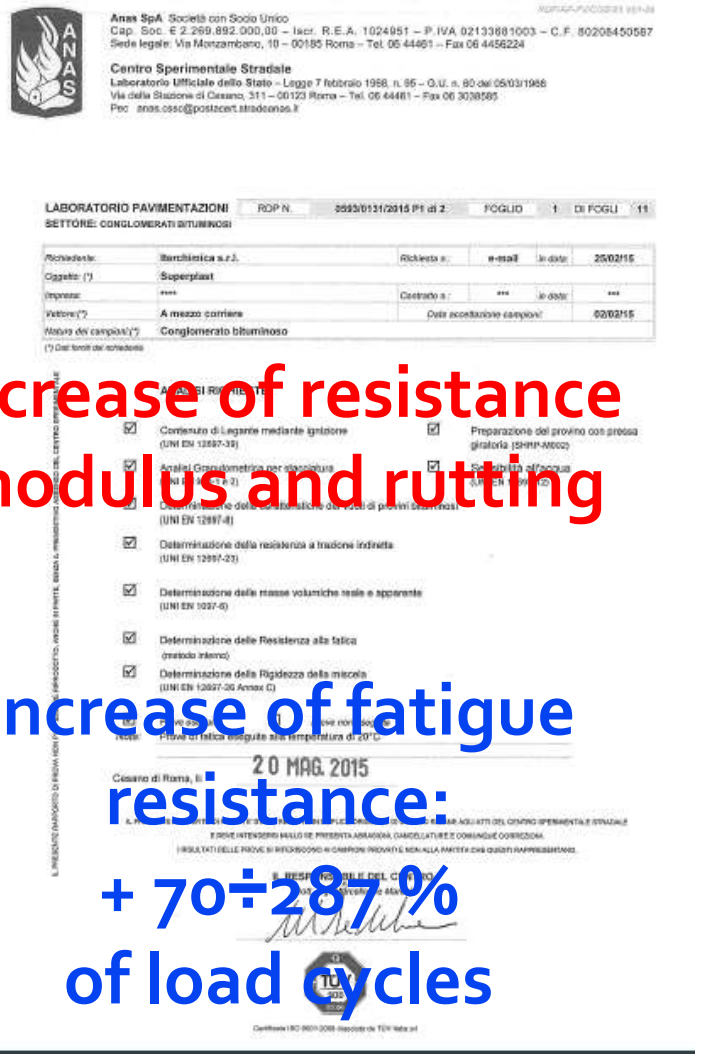
**DOSAGE SYSTEM**

# Benefits due to PMB and PMA Technologies

| PARAMETER | PMB | PMA |
|---|---|---|
| High stiffness MODULUS | ✓ | ✓ |
| Increase RUTTING resistance | ✓ | ✓ |
| Reduction vertical deformation | ✓ | ✓ |
| Increase FATIGUE CRACKING resistance | ✓ | ✓ |
| Optimum DOSAGE in function of the mix | | ✓ |
| High MECHANICAL PROPERTIES | ✓ | ✓ |
| THERMAL FLUCTUATIONS CONDITION | ✓ | ✓ |
| SAVE ENERGY during the production | | ✓ |

# PMB vs PMA

| | | PMA con SUPERPLAST al 5% | | PMB | |
|---|---|---|---|---|---|
| Penetrazione | [°C] | Bitume Normale | 53 | Bitume Modificato Hard | 48 |
| Rammollimento | [°C] | | 48,4 | | 85,3 |
| Indice di Penetrazione | [n] | | -1,5 | | 4,9 |
| Rottura Fraass | [°C] | | -9 | | -13 |
| Ritorno Elastico | [%] | | --- | | 90 |
| BITUME | [% su mix] | 4,58 | | 4,52 | |
| Gsb | [g/cm3] | 2,52 | | 2,52 | |
| Vuoti N1 = 10 | [%] | 10,8 | | 11,9 | |
| Vuoti N2 = 120 | [%] | 1,8 | | 2,1 | |
| Vuoti N3 = 200 | [%] | 0,9 | | 1,1 | |
| | | | | | |
| ITS @ 25°C | [GPa x 10-3] | 2,0 | | 1,4 | |
| CTI @ 25°C | [GPa x 10-3] | 267 | | 172 | |
| ITS @ 40°C | [GPa x 10-3] | 0,6 | | 0,7 | |
| CTI @ 40°C | [GPa x 10-3] | 64 | | 70 | |
| ITSR | [%] | 91 | | 96 | |
| | | | | | |
| Vuoti 180 cicli | [%] | 2,3 | | 3,4 | |
| Stiffness @ 20°C | [MPa] | 8.676 | | 6.271 | |
| Stiffness @ 40°C | [MPa] | 1.784 | | 1.645 | |
| Fatica: σ @ 0,2 N/mm2 | [Cicli] | 1.550.000 | | 900.000 | |
| Fatica: σ @ 0,3 N/mm2 | [Cicli] | 456.500 | | 237.500 | |
| Fatica: σ @ 0,4 N/mm2 | [Cicli] | 98.982 | | 54.500 | |
| Fatica: σ @ 0,5 N/mm2 | [Cicli] | 46.500 | | 12.000 | |




**Increase of resistance modulus and rutting**

**Increase of fatigue resistance: + 70÷287 % of load cycles**

# Case Histories

## MORE THAN 4.000 Km (2010 - 2016)
## *OF ROADS REALIZED WITH OUR POLYMERS*

***Some References:***

1. *2013 – ALGERIA* **150 Km of highway**

Highway RN01 between Ksar El Boukhari and Boughzol

2. *2012 – ROMANIA* **50 Km of National Road and highway**

DN 79 Arad-Oradea and Costanta Highway

3. *2016 – EGYPT* **Trial Section**

Cairo Alexandri Agricultural Road

4. *2010 – LIBYA* **240 km of Highways**

Sebha-Brak Road and Libyan Coastal Highway

5. *2016 – GREECE* **30 Km of Highway**

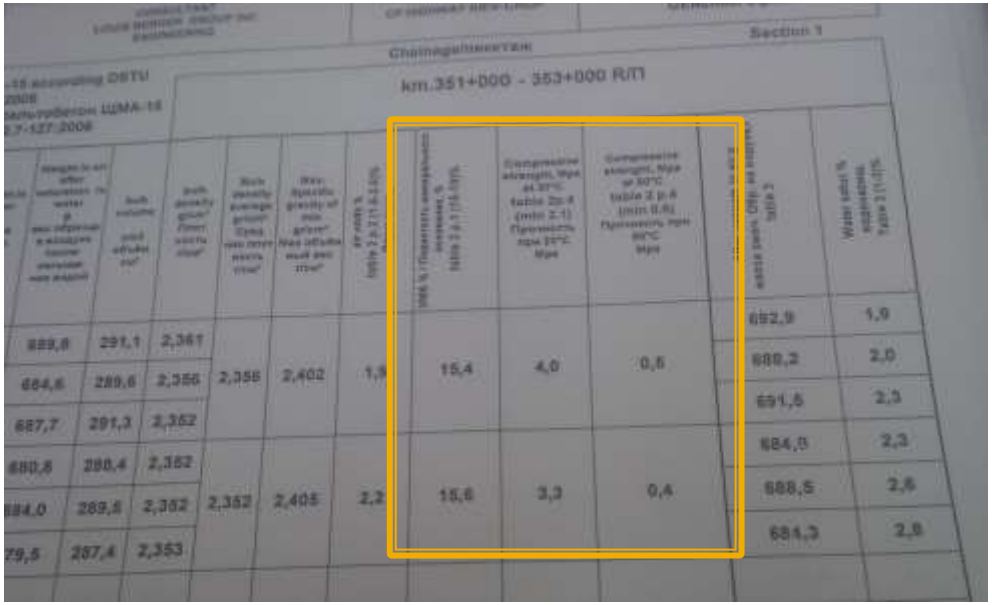
Highway Egnatia – Odos

## NO RUTTING PHENOMENA UNTIL TODAY

# *MIX DESIGN STUDY WITH SUPERPLAST and PROJECT*

Reaching the limit of the Ukraine Technical Specifications using POLYMERIC compound added directly in the mixer for bituminous mixes resistant to **LOW** temperatures:

- **Goal: Certification of the compound for projects in Ukraine;**
- **Approval of the Mix Design for the project**




## *Highway Mo6 Kyiv Chop*

# Case Histories-Ukraine

## *M06 Kyiv-Chop*

**SUPERPLAST-ITERFIBRA C/PLUS-ITERLOW T-ITERLENE IN 400 S**

*More than180 Km*

## *M03 Kiev- Karkhiv - Dovzhanskiy*

**SUPERPLAST-ITERFIBRA C/PLUS-ITERLOW T-ITERLENE IN 400 S**

*More than 120 Km*

# Case Histories-Romania

## *CERTIFICATION SUPERPLAST and PROJECTS*

Reaching the limits of the Romanian Technical Specifications using POLYMERIC compound added directly in the mixer for highway projects:

- **Bituminous mix type BDM 0/25;**
- **Bituminous mix type BC 0/16;**

REALIZATION OF DIFFERENT HIGHWAY SECTIONS

- **A1**
- **A2**
- **A3**
- **A4**

**Crossing of climatic areas very different**

**POLYMER COMPOUND**

**682 km - WEARING COURSE AND BINDER**

# DBM 0/25: Performances obtained

| DBM 0/25 mm with 5% on bitumen of COMPOUND OF POLYMERS – Compaction with gyratory press, EN 12697-31 | | | | |
|---|---|---|---|---|
| **Characteristics** | **UM** | **Typical values** | **Technical Specifications** | **Test method** |
| Voids at 120 cycles | % | 3,6 | ≤ 9,5 | EN 12697-31 |
| Stiffness modulus, T = 15°C and f = 2 Hz | MPa | 10 300÷10 800 | ≥ 4 000 | EN 12697-26 |
| Dynamic Creep, T = 40°C and 1800 pulses of 200 kPa:<br>- Deformation<br>- Deformation speed | mm/m<br>mm/m/cycle | 2 815÷3 642<br>0,13÷0,12 | ≤ 20 000<br>≤ 2,00 | EN 12697-25 |
| Fatigue resistance , T = 15°C | Number of cycles at breaking | **> 420 000** | **≥ 400 000** | EN 12697-24-A1 |

# BC 0/16: Performances obtained

| BC 0/16 mm with 5% on bitumen of COMPOUND OF POLYMERS – Compaction with gyratory press, EN 12697-31 | | | | |
|---|---|---|---|---|
| **Characteristics** | **UM** | **Typical values** | **Technical specifications** | **Test method** |
| Apparent density | Kg/m$^3$ | 2 367 | ≥ 2 350 | EN 12697-6-A1 |
| Voids at 80 cycles | % | 4,0 | ≤ 5,0 | EN 12697-31 |
| Stiffness modulus, T = 15°C and f = 2 Hz | MPa | 7 350÷8 850 | ≥ 4 500 | EN 12697-26 |
| Dynamic Creep, T = 40°C and 1800 pulses of 200 kPa:<br>- Deformation<br>- Deformation speed | mm/m<br>mm/m/cycle | 13 600÷14 800<br>1,03÷0,96 | ≤ 25 000<br>≤ 2,50 | EN 12697-25 |
| Rutting test<br>- $PRD_{AIR}$<br>- $WTS_{AIR}$ | %<br>Mm/1000 cycle | < 6,8<br>< 0,07 | ≤ 7,0<br>≤ 0,7 | EN 12697-22 |

# Case Histories-Romania

## ***DN 79 Arad-Oradea***

**COMPOUND OF POLYMERS – ITERFIBRA C/PLUS – ITERLENE IN 400 S**

*More than100 Km*


## ***Costanta Highway***

**COMPOUND OF POLYMERS – ITERFIBRA C/PLUS – ITERLENE IN 400 S**

*More than 30 Km*

# Case Histories-Greece

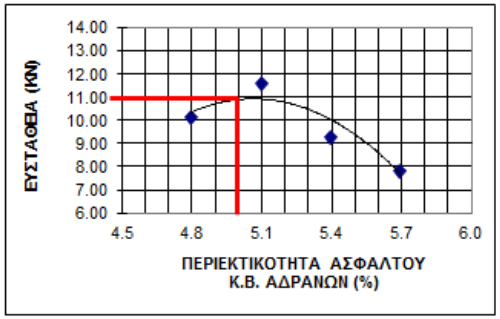
## ***Highway Egnatia - Odos More than 30 Km***

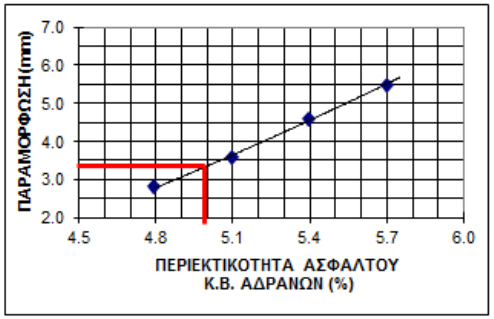
**COMPOUND OF POLYMERS**


# Case Histories-Greece

| % ΑΣΦΑΛΤΟΣ | % ΚΕΝΑ | ΦΑΙΝΟΜΕΝΗ ΠΥΚΝΟΤΗΤΑ | ΕΥΣΤΑΘΕΙΑ [KN] | ΠΑΡΑΜΟΡΦΩΣΗ [mm] | VMA | VFB |
|---|---|---|---|---|---|---|
| 4,8 | 8,4 | 2,403 | 10,13 | 2,8 | 19,19 | 56,5 |
| 5,1 | 7,0 | 2,423 | 11,60 | 3,6 | 18,66 | 62,4 |
| 5,4 | 5,6 | 2,448 | 9,32 | 4,6 | 18,04 | 69,2 |
| 5,7 | 4,4 | 2,464 | 7,89 | 5,5 | 17,71 | 75,0 |

**5% optimal bitumen content**


1. **7,5% of Air Voids** at 5% optimal bitumen content (Specification limits between 5% to 10%);
2. **11 KN Marshall Stability** at 5% optimal bitumen content;
3. **3,4 mm Flow** at 5% optimal bitumen content;

**< 7 mm Ruth Depth**
***Under Specification***

## *Official Laboratory of the Polytechnic in Milan*

| | SMA Pmb | SMA Superplast |
|---|---|---|
| Fraction 8/11 mm [%] | 32.0 | |
| Fraction 4/8 mm [%] | 38.5 | |
| Fraction 0/2 mm [%] | 12.2 | |
| Filler [%] | 11.3 | |
| Iterfibra C–Plus (on mix) [%] | 0.4 | 0.4 |
| Bitumen (on mix) [%] | 5.6 (Pmb) | 5.6 (Neat Bitumen) |
| Superplast (on bitumen) [%] | - | 4.5 |
| Iterlene PE 31-F (on bitumen) [%] | - | 0.15 |

***Performances obtained are completely* EQUIVALENT**

| TEST | PARAMETHER | SMA PMB | SMA SUPERPLAST |
|---|---|---|---|
| *DETERMINATION OF STIFFNESS MODULUS* | Stiffness Modulus at 5°C [MPa] | 10.183 | 10.959 |
| | Stiffness Modulus at 20°C [MPa] | 3.752 | 5.285 |
| | Stiffness Modulus at 40°C [MPa] | 1.282 | 1.665 |
| *DETERMINATION OF RUTTING RESISTANCE* | Rut Depth at 10000 cycles [mm] | 1,71 | 2,18 |
| | PRD $_{air\ 10000}$ [%] | 2,9 | 3,7 |
| *DETERMINATION OF RESISTANCE TO FATIGUE* | Number of Cycles [%] | 2.147.192 | 2.583.048 |

# Case Histories-Italy

## ***Milano Malpensa International Airport***

**SUPERPLAST**

*Runways*

## ***Italian Highways – Pavia-Bereguardo***

**SUPERPLAST**


# Croatia References

**Tablica A2:** Najviše dopuštene temperature uskladištenog bitumena

| Vrsta bitumena | Tip bitumena | Najviša dopuštena temperatura, °C |
|---|---|---|
| Cestograđevni bitumen | 20/30 | 200 |
| | 35/50 | 190 |
| | 50/70 | 180 |
| | 70/100 | 180 |
| | 160/220 | 170 |
| Tvrdi cestograđevni bitumen | 10/20 | 200 |
| | 15/25 | 200 |
| Polimerom modificirani bitumen | 10/40-65 | 190 |
| | 25/55-55 | 180 |
| | 45/80-65 | 180 |
| | 45/80-55 | 180 |
| | 40/100-65 | 180 |

olimerom modificiranog bitumena

| | | | HRN EN 14023 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tip | | | | | | | | | | | |
| spitna norma | | | 10/40-65 | | 25/55-55 | | 45/80-55 | | 45/80-65 | | 40/100-65 | | 90/150-45 | |
| | | | Raz. | Zahtjev | Raz. | Zahtjev | Raz. | Zahtjev | Raz. | Zahtjev | Raz. | Zahtjev | Raz. | Zahtjev |
| N EN 1426 | | | 2 | 10 - 40 | 3 | 25 - 55 | 4 | 45 - 80 | 4 | 45 - 80 | 5 | 40 - 100 | 8 | 90 - 150 |
| N EN 1427 | | | 5 | ≥ 65 | 7 | ≥ 55 | 7 | ≥ 55 | 5 | ≥ 65 | 5 | ≥ 65 | 9 | ≥ 45 |
| EN 13703 i EN 13589 | | | 6 | ≥ 2 | - | - | - | - | - | - | - | - | - | - |
| | | | | - | 2 | ≥ 3 | 2 | ≥ 3 | 2 | ≥ 3 | 2 | ≥ 3 | 2 | ≥ 3 |
| 5.2.8.2 | Točka paljenja, °C | | HRN EN ISO 2592 | 2 | ≥ 250 | 2 | ≥ 250 | 2 | ≥ 250 | 2 | ≥ 250 | 2 | ≥ 250 | 2 | ≥ 250 |
| 5.2.8.3 | Gustoća na 25 °C, kg/m³ | | HRN EN 15326 | - | *navesti* | - | *navesti* | - | *navesti* | - | *navesti* | - | *navesti* | - | *navesti* |
| Tablica 2 | Točka loma po Fraassu, °C | | HRN EN 12593 | 3 | ≤ -5 | 5 | ≤ -10 | 6 | ≤ -12 | 7 | ≤ -15 | 7 | ≤ -15 | 8 | ≤ -18 |
| | Elastični povrat na 25 °C, % [a] | | HRN EN 13398 | 5 | ≥ 50 | 5 | ≥ 50 | 4 | ≥ 60 | 2 | ≥ 80 | 2 | ≥ 80 | 2 | ≥ 80 |
| | Stabilnost pri skladištenju | Δ PK, °C | HRN EN 13399 i HRN EN 1427 | 2 | ≤ 5 | 2 | ≤ 5 | 2 | ≤ 5 | 2 | ≤ 5 | 2 | ≤ 5 | 2 | ≤ 5 |
| | | Δ Pen, 0,1 mm | HRN EN 13399 i HRN EN 1426 | 0 | *NR* | 0 | *NR* | 0 | *NR* | 0 | *NR* | 0 | *NR* | 0 | *NR* |
| *Otpornost na otvrdnjavanje (HRN EN 12607-1)* | | | | | | | | | | | | | | |
| 5.2.6 | Promjena mase, %(m/m) | | HRN EN 12607-1 | 3 | ≤ 0,5 | 3 | ≤ 0,5 | 3 | ≤ 0,5 | 3 | ≤ 0,5 | 3 | ≤ 0,5 | 3 | ≤ 0,5 |
| | Zadržana penetracija, % | | HRN EN 1426 | 6 | ≥ 55 | 6 | ≥ 55 | 6 | ≥ 55 | 6 | ≥ 55 | 6 | ≥ 55 | 6 | ≥ 55 |
| | Porast točke razmekšanja, °C | | HRN EN 1427 | 2 | ≤ 8 | 2 | ≤ 8 | 2 | ≤ 8 | 2 | ≤ 8 | 2 | ≤ 8 | 2 | ≤ 8 |
| Tablica 2 | Pad točke razmekšanja, °C | | HRN EN 1427 | 2 | ≤ 2 | 2 | ≤ 2 | 2 | ≤ 2 | 2 | ≤ 2 | 2 | ≤ 2 | 2 | ≤ 2 |
| | Elastični povrat na 25 °C, % [a] | | HRN EN 13398 | 4 | ≥ 50 | 4 | ≥ 50 | 4 | ≥ 50 | 2 | ≥ 70 | 2 | ≥ 70 | 2 | ≥ 70 |
| [a] odnosi se isključivo na bitumen modificiran elastomerom | | | | | | | | | | | | | | |

## PMA technology

Using the **PPS (Polymer-Fiber) is possible to guarantee these parameters (Table F3)**

## LABORATORY TESTS

# Croatia references - PMA solution

**Tablica A2:** Najviše dopuštene temperature uskladištenog bitumena

| Vrsta bitumena | Tip bitumena | Najviša dopuštena temperatura, °C |
|---|---|---|
| Cestogrаđevni bitumen | 20/30 | 200 |
| | 35/50 | 190 |
| | 50/70 | 180 |
| | 70/100 | 180 |
| | 160/220 | 170 |
| Tvrdi cestogrаđevni bitumen | 10/20 | 200 |
| | 15/25 | 200 |

| Asfaltbeton za habajuće slojeve HRN EN 13108-1 (empirijski pristup) | | Tipovi asfaltbetona za habajuće slojeve | | | |
|---|---|---|---|---|---|
| | | M1-E | M2-E | M3-E | M4-E |
| | | AC 11 *surf* | AC 8 *surf*<br>AC 11 *surf* | AC 8 *surf*<br>AC 11 *surf* | AC 4 *surf*<br>AC 8 *surf*<br>AC 11 *surf*<br>AC 16 *surf* |
| Sastavni materijali | Primjenska oznaka smjese agregata | *AG1* | *AG1, AG2, AG5* | *AG1* do *AG4* | *AG1* do *AG4, AG9* [d] |
| | Cestogrаđevni bitumen | - | 35/50 [e] | 35/50<br>50/70<br>70/100 | 50/70<br>70/100<br>160/220 |
| | Polimerom modificirani bitumen | 25/55-55<br>45/80-65<br>45/80-55 | 25/55-55<br>45/80-65<br>45/80-55 | 25/55-55<br>45/80-65<br>45/80-55 | - |
| | Reciklažni asfaltni agregat | nije dopušten | dopušten | | |
| *Fizikalno-mehanička svojstva bitumenske mješavine* | | | | | |
| Točka 5.2.2 [a] | Udio šupljina, *V* % (*V/V*) | $V_{min3,5}$ | $V_{min3,5}$ | $V_{min3}$ | $V_{min\,2,5}$ |
| | | $V_{max6}$ | $V_{max6}$ | $V_{max6}$ | $V_{max5,5}$ |
| Točka 5.3.3 [a] | Ispuna šupljina bitumenom, *VFB* (%) | $VFB_{minNR}$ | $VFB_{minNR}$ | $VFB_{min65}$ | $VFB_{min70}$ |
| | | $VFB_{maxNR}$ | $VFB_{maxNR}$ | $VFB_{max83}$ | $VFB_{max86}$ |
| Točka 5.2.4 [b] | Najmanji omjer indirektne vlačne čvrstoće, *ITSR* (%) | $ITSR_{80}$ | $ITSR_{80}$ | $ITSR_{80}$ | $ITSR_{70}$ |
| Točka 5.2.6 [c] Tablica 8 | Najveća brzina deformacije, $WTS_{AIR}$, (mm/$10^4$ ciklusa) | $WTS_{AIR\,0,07}$ | $WTS_{AIR\,0,07}$ | $WTS_{AIR\,NR}$ | |
| Točka 5.2.6 [c] Tablica 9 | Najveća relativna dubina kolotraga, $PRD_{AIR}$ (%) | $PRD_{AIR\,7,0}$ | $PRD_{AIR\,5,0}$ | $PRD_{AIR\,NR}$ | |
| Točka 5.3.4 | Najmanji udio šupljina u agregatu $VMA_{min}$, % (*V/V*) | | | $VMA_{minNR}$ | |
| Točka 5.2.5 | Otpornost na abraziju gumama s čavlima, $Abr_A$, (ml) | | | $Abr_{ANR}$ | |

**Neat Bitumen**

**Mechanical performance like a modify bitumen**

**PMA technology**

Using the **PPS or Polymers is possible to guarantee these parameters**

# Croatia References

Considering the mechanical performance is possible to improve the limits inside the references with dynamic tests and introduce the PMA solution like in Italy, Romania, etc.

## ITALY

### Base course with modify bitumen

| | | |
|---|---|---|
| T=5°C, Def.=7µm, Freq.=2Hz, Coeff.P.=0.35 | MPa | 10.000-16.000 |
| T=20°C, Def.=7µm, Freq.=2Hz, Coeff.P.=0.35 | MPa | 4.000-7.000 |
| T=40°C, Def.=7µm, Freq.=2Hz, Coeff.P.=0.35 | MPa | 600-1.500 |

### Base course with polymers

| | | | |
|---|---|---|---|
| T=5°C, Def.=7µm, Freq.=2Hz, Coeff.P.=0.35 | MPa | 12.000-21.000 | 14.000-25.000 |
| T=20°C, Def.=7µm, Freq.=2Hz, Coeff.P.=0.35 | MPa | 5.000-8.000 | 7.000-12.000 |
| T=40°C, Def.=7µm, Freq.=2Hz, Coeff.P.=0.35 | MPa | 600-2.000 | 800-4.000 |

**Low dosage** **High dosage**


Area Manutenzione Opere Stradali e Civili

Lavori di manutenzione delle pavimentazioni stradali
TRATTO: AUTOSTRADA A50 TANGENZIALE OVEST DI MILANO E PERTINENZE

GARA LAVORI OSC 03/2016

Capitolato Speciale d'Appalto
SPECIFICHE TECNICHE

## ROMANIA

Tabelul 17 – Caracteristicile mixturilor pentru stratul de legătură determinate prin încercări dinamice

| Nr. crt. | Caracteristica | Mixtură asfaltică pentru stratul de legătura | |
|---|---|---|---|
| | | I-II | III-IV |
| 1. | **Caracteristici pe cilindrii confecționați la presa giratorie** | | |
| 1.1. | **Volum de goluri, la 120 giratii,% maxim** | 9,5 | 10,5 |
| 1.2. | Rezistența la deformații permanente (fluaj dinamic)<br>- deformația la 40 °C, 200KPa și 10000 impulsuri, µm/m, maxim<br>- viteza de deformație la 40 °C, 200KPa și 10000 impulsuri, µm/m/ciclu, maxim | 20 000<br>2 | 30 000<br>3 |
| 1.3. | **Modulul de rigiditate la 20 °C, 124 ms, MPa, minim** | 5000 | 4500 |
| 1.4. | **Rezistența la oboseală,** proba cilindrică solicitată la întindere indirectă : Număr minim de cicluri până la fisurare la 15°C | 400 000 | 300 000 |
| 2. | **Rezistența la oboseală,** epruvete trapezoidale sau prismatice<br>Deformația $\varepsilon^6$ la $10^6$ cicluri, $10^{-6}$ | 200 | 250 |

NORMATIV

MIXTURI ASFALTICE EXECUTATE LA CALD . CONDIȚII TEHNICE PRIVIND PROIECTAREA, PREPARAREA ȘI PUNEREA ÎN OPERĂ

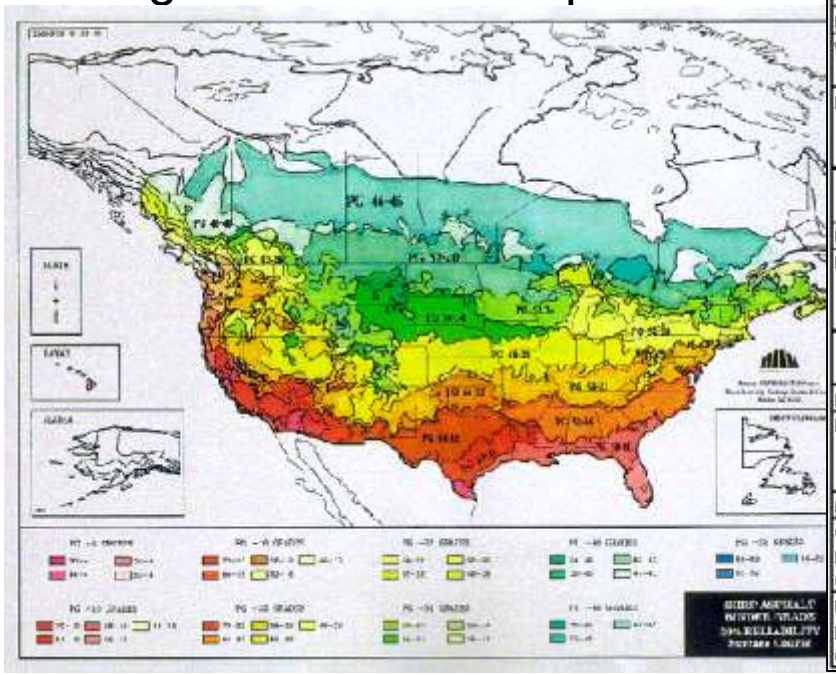
SECȚIUNEA 4
Aditivi

**Art.36.** În vederea atingerii performanțelor mixturilor asfaltice, la nivelul cerințelor, se pot utiliza aditivi, cu caracteristici declarate, evaluați în conformitate cu legislația în vigoare. Acești aditivi pot fi adăugați fie direct în bitum, cum sunt de exemplu agenții de adezivitate sau aditivii de mărire a lucrabilității, fie în mixtura asfaltică, cum sunt de exemplu fibrele minerale sau organice, polimerii, etc.

# Pavement-Temperature

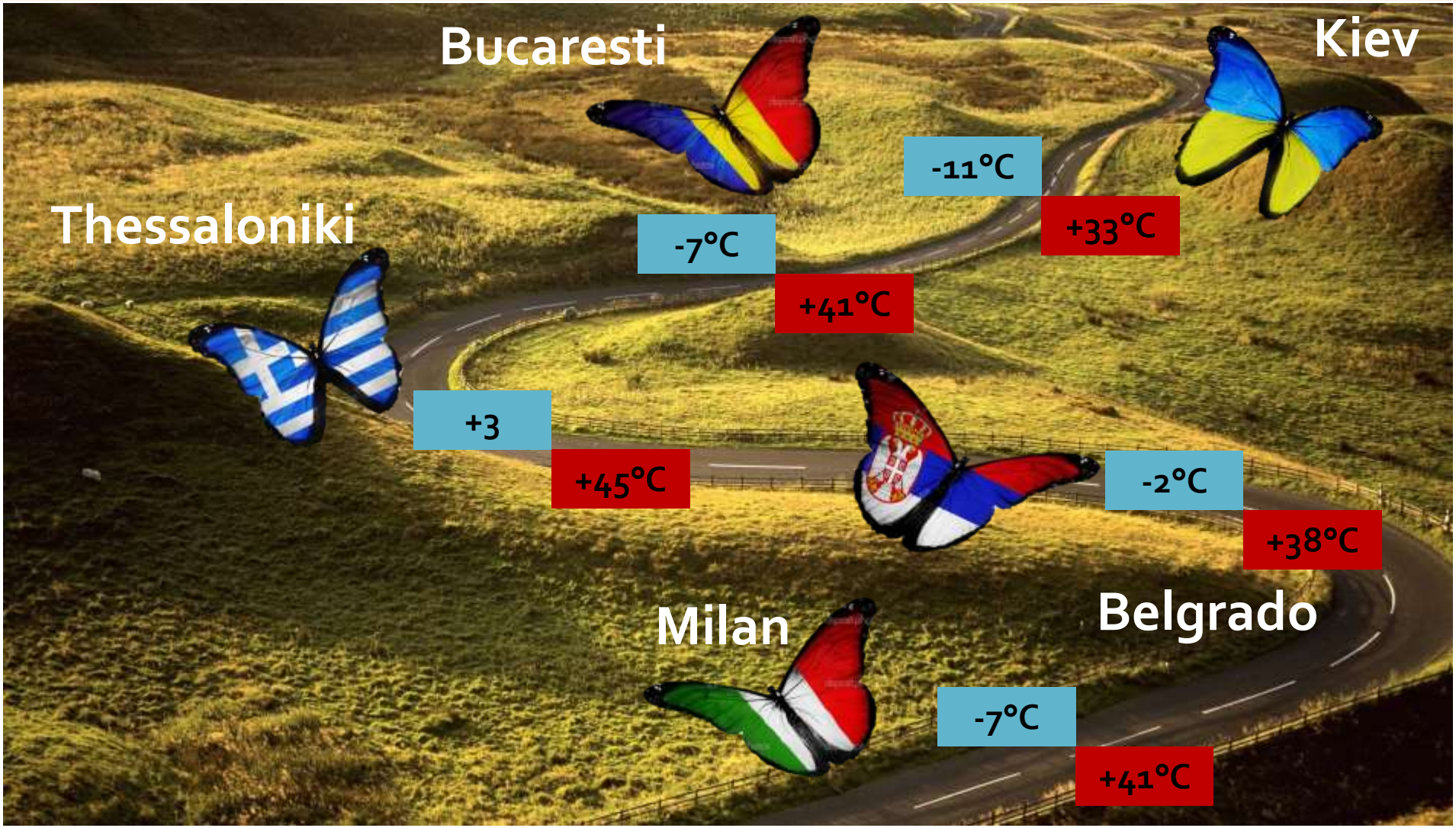
**PG 58 – 22** → **Min** Design Pavement temperature

↓ **Max** Design Pavement temperature

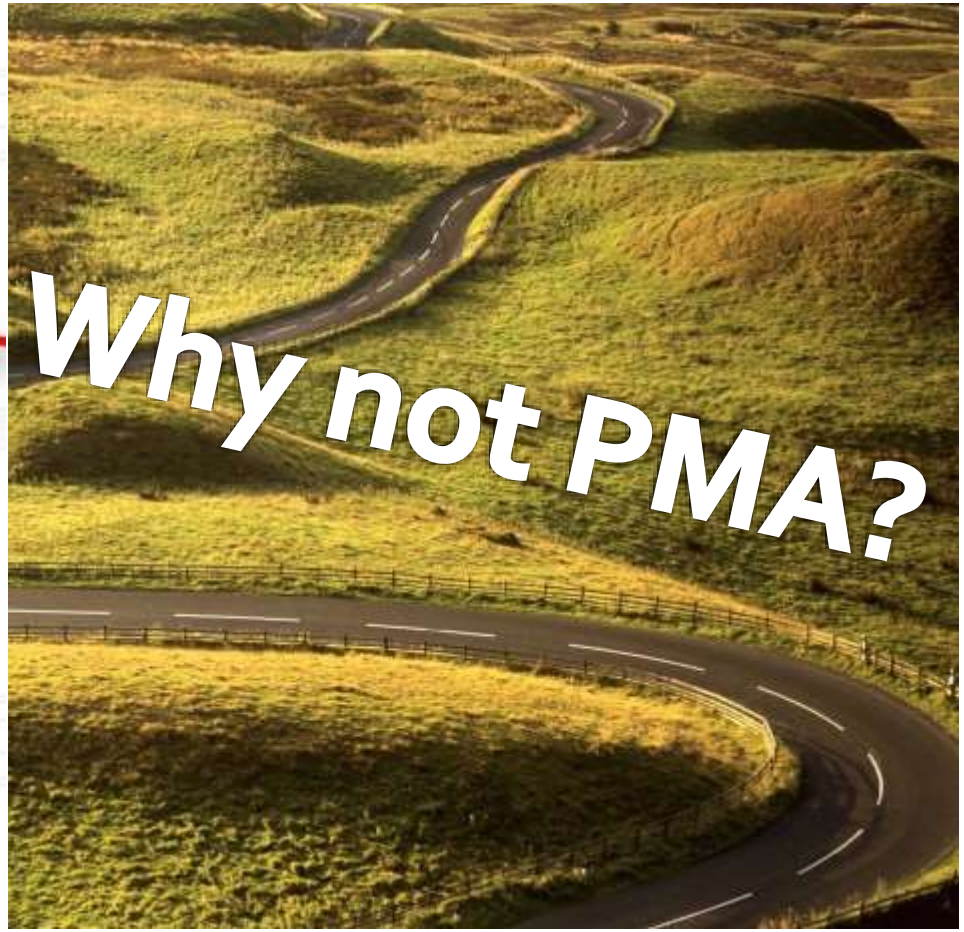


| Performance Grade | PG 70 | | | | | | PG 76 | | | | | PG 82 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 16 | 22 | 28 | 34 | 40 | 10 | 16 | 22 | 28 | 34 | 10 | 16 | 22 | 28 | 34 |
| Average 7-day Maximum Pavement Design Temperature, °C[2] | < 70 | | | | | | < 76 | | | | | < 82 | | | | |
| Minimum Pavement Design Temperature, °C[2] | -10 | -16 | -22 | -28 | -34 | -40 | -10 | -16 | -22 | -28 | -34 | -10 | -16 | -22 | -28 | -34 |
| **ORIGINAL BINDER** | | | | | | | | | | | | | | | | |
| Flash Point Temp, T 48, Minimum (°C) | 230 | | | | | | | | | | | | | | | |
| Viscosity, ASTM D 4402[1] Maximum, 3 Pa*s, Test Temp, °C | 135 | | | | | | | | | | | | | | | |
| Dynamic Shear, TP 5[1] G*/sinδ, Minimum, 1.00 kPa Test Temp @ 10 rad/s, °C | 70 | | | | | | 76 | | | | | 82 | | | | |
| **ROLLING THIN FILM OVEN RESIDUE (T 240)** | | | | | | | | | | | | | | | | |
| Mass Loss, Maximum, percent | 1.00 | | | | | | | | | | | | | | | |
| Dynamic Shear, TP 5 G*/sinδ, Minimum, 2.20 kPa Test Temp @ 10 rad/s, °C | 70 | | | | | | 76 | | | | | 82 | | | | |
| **PRESSURE AGING VESSEL RESIDUE (PP 1)** | | | | | | | | | | | | | | | | |
| PAV Aging Temperature, °C[2] | 100 (110) | | | | | | 100 (110) | | | | | 100 (110) | | | | |
| Dynamic Shear, TP 5 G*sinδ, Maximum, 5000 kPa Test Temp @ 10 rad/s, °C | 34 | 31 | 28 | 25 | 22 | 19 | 37 | 34 | 31 | 28 | 25 | 40 | 37 | 34 | 31 | 28 |
| Physical Hardening[3] | Report | | | | | | | | | | | | | | | |
| Creep Stiffness, TP 1 Determine the critical cracking temperature as described in PP 42 | 0 | -6 | -12 | -18 | -24 | -30 | 0 | -6 | -12 | -18 | -24 | 0 | -6 | -12 | -18 | -24 |
| Direct Tension, TP 3 Determine the critical cracking temperature as described in PP 42 | 0 | -6 | -12 | -18 | -24 | -30 | 0 | -6 | -12 | -18 | -24 | 0 | -6 | -12 | -18 | -24 |

# Pavement-Temperature



# Pavement-Temperature


**The temperature range can be compare with others European Country close to Croatia**

# Thanks for your attention

## *Hvala na pažnji*

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