WCPAM 2017
WORLD CONFERENCE ON PAVEMENT AND ASSET MANAGEMENT
Baveno, Italy - June 12/16, 2017

Natural bitumen – the perfect additives for high-performance asphalt mixes

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Selenice Bitumi Sha

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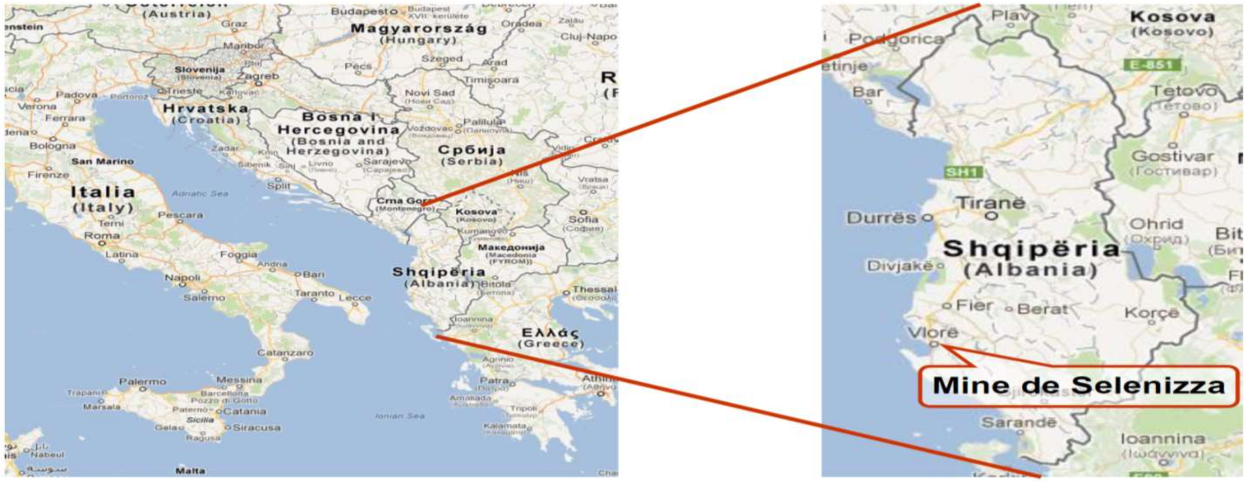
Summary

1. ***Characterisitcs of Albanian natural bitumen***
2. ***Natural asphalts as modifiers of distillation bitumen: thermo-rheological characterization***
3. ***Environmental impact assessment***
4. ***Implementation examples***
5. ***Conclusions***

1

Characteristics of Albanian natural bitumen

- The mine of **Selenice** is located in southeast **Albania.**
- **It has been mentioned** since ancient times **by Aristotle &** actively exploited by **the Romans**.
- in **1868,** The French **geologist Coquand** published a **geological description**
- The **ottoman government** transferred rights to the **French** (1871), **Italians** (1919-1943).
- After the World War II exploited by the **Albanian** government.
- **Since 2001**, the mine is managed by the **French company KLP Industries**



- A **PhD thesis** was recently presented at the University of Strasbourg in France, on the **potential of using** natural bitumen in the production of **hard penetration grade binders** and **high modulus asphalt mixes** that lead to implementation **of cost effective** pavements (thin and long lasting pavement layers)

- **The study,** in line with the strategy of **sustainable industrial development**, **proposes an alternative method** using natural bitumen to produce HMA **aging resistant** and relatively **efficient at low temperatures**.

- These researches are **very topical at this time,** considering the **problems encountered** while using **hard petroleum bitumen** such **as the risk of cold cracking, rapid aging, supply difficulties,** as well as the **inability to produce hard bitumen** from certain crude oils

The analysis of **physico-chemical properties** of natural bitumen showed that its **organic phase is similar to** that of petroleum bitumen but having the specificity of **high content** of **polar fractions** (resin + aspahltene), resulting in a **vitrous transition** at **higher temperatures,** and in an **enhanced adhesion** between the **bitumen** and **mineral aggregates**

SARA IATROSCAN method		**Saturated [%]**	**Aromatic [%]**	**Resin [%]**	**Asphaltene-i [%]**	**I_c**
Purified sample-depth	Average Standard deviation	1,7 0,35	24,8 2,29	35,1 1,35	38,4 1,88	0,67
Purified sample-surface	Average Standard deviation	1,5 0,14	22,7 1,37	37,2 1,90	38,6 1,58	0,67
Raw sample-depth	Average Standard deviation	1,6 0,29	23,8 1,40	34,6 1,16	40,01 1,99	0,71
Raw sample-surface	Average Standard deviation	1,6 0,24	19,7 2,02	37,9 1,60	40,8 2,74	0,73

The colloidal instability index **I_c** values, **indicate** that the organic phases of the asphaltite Selenizza® have a **sol** or **sol-gel** character**,** with a sufficient quantity of resins to peptize the asphaltenes

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Vitreous transition characterization with **differential calorimetric** analysis. **T_g** correlated to the **mechanical behaviour** of bitumen **at low temperatures. High T_g means brittle behaviour.** Typically, for bitumen, T_g ranges between **-50 to -10°C.** Above the glass transition, the **thermal effects** are dominated from the **fusion of crystallisable fractions** (detrimental to the **cracking resistance**) with crystallization temperatures -10 to 60 °C.

	Total heat flux				
	T_g1 [°C]	T_g [°C]	T_g2 [°C]	ΔT_g [°C]	$\Delta\Phi$ [W/g]
Albanian natural bitumen	-13,77	-0,34	15,35	29.12	0.025

The mineral phase composition contained in natural bitumen (determined with infrared spectroscopy) ranges between **15 to 20 %,** and is composed of **SiO_2, $CaCO_3$** and various **clay minerals.** It is similar to petroleum bitumen, but **stiffer** due to higher content of **resins** and **asphaltenes**

Softening point	**TR&B[°C]**	
	Average	Standard deviation
Albanian natural bitumen	114,9 – 119,9	0,71 – 1,84

Complex modulus	**Measures at 100°C, 5 Hz**	
	$\|E^*\|$ [GPa]	**δ [°C]**
Albanian Natural Bitumen	0,95 - 1,27	48,3 - 51,7

The **impact** of adding **different percentages** of the Albanian natural bitumen to the **mechanical properties** of modified bitumen was measured in terms of penetrability and TR&B

Description	Penetration [dmm]	TR&B[°C]	Penetration Index	Grade obtained
Petroleum bitumen 50/70	54	49,0	-1,28	-
Mixed with 5% natural bitumen	38	52,6	-1,18	35/50
Mixed with 10% natural bitumen	28	56,2	-1,01	20/30
Mixed with 15% natural bitumen	20	-61,6	-0,60	10/20
Natural Bitumen	0	120,0	-0,18	-

The **Penetration index** which reflects the **temperature susceptibility** of bitumen, decreased as the % of natural bitumen increased

$$\log Pm = \log Pn + x \,.\, (\log Pa - \log Pb)$$

$$Tm = Tb + x * (Ta - Tb)$$

Differental scanning calorimetry showed that **the addition** of natural bitumen **does not affect** the **glass transition** of bitumen. At the same time it was noted a **slight decrease** of the **crystallizable fraction contents**, **with the percentage** of the modifier used

	Total heat flux				
	T_g1 [°C]	T_g [°C]	T_g2 [°C]	ΔT_g [°C]	$\Delta\Phi$ [W/g]
Petroleum bitumen 50/70	-31,9	-22,9	-13,2	18,6	0,022
Mixed with 5% SLN	-30,9	**-23,1**	-13,8	17,1	0,019
Mixed with 10% SLN	-30,3	-23,1	-13,3	17,0	0,018
Mixed with 15% SLN	-32,1	-23,3	-13,4	18,8	0,019
Natural asphaltite SLN	-12,6	-1,1	16,2	28,8	0,021

It should be noted that the analysis of mechanical behavior at low temperatures comparing a **35/50 modified** bitumen (**50/70 + 5% Selenizza)** with a **petroleum bitumen** having the same penetration grade 35/50, showed that the **glass transition temeprature** of modified bitumen (typically ranging from -50 to -10°C), was **T_g = - 23.1°C** versus **T_g = -19.3°C** for the petroleum bitumen with equivalent penetration grade, which indicates **a better resistance** of natural bitumen **to brittle fracture**

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Aging effect

- An important factor determining the durability and sustainability of the construction works is the **aging behaviour of bitumen**.

- To evaluate the **aging behavior,** different hard bitumen specimens obtained by modification with natural bitumen, have been submitted to **accelerated aging RTFOT** tests (to simulate oxidation of bitumen during mixture manufacturing) as well as **PAV** (to simulate in-service ageing)

- It was observed that the **aging leads** to bitumen **hardening** which is **evidenced by** the **decrease of penetration** and **increase softening point** temperature TR&B. It is also manifested in an increase of **complex modulus** and **elasticity** (phase angle decrease)

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Description	Penetration (dmm)					TR&B (°C)				
	New binder	After RTFOT	Δ_1 (%)	After PAV	Δ_2 (%)	New binder	After RTFOT	Δ_1 (%)	After PAV	Δ_2 (%)
Petroleum 50/70	54	37	31.5	19	64.8	49	53.4	8.9	61.4	25.3
Mixed with 5%	38	27	28.9	15	60.5	52.6	57.2	8.7	66.0	25.4
Mixed with 10%	28	21	25	13	53.5	56.2	60.8	8.1	68.8	22.4
Mixed with 15%	20	14	30	11	45	61.6	65.4	6.1	72.2	17.2
Petroleum 35/50	40	27	32.5	12	70	52.6	56.8	7.9	66.2	25.8
Petroleum 20/30	23	12	47.8	7	69.5	60.0	67.0	11.6	78.8	31.3
Petroleum 10/20	18	9	50	5	72.2	65.0	72.6	11.7	86.0	32.3

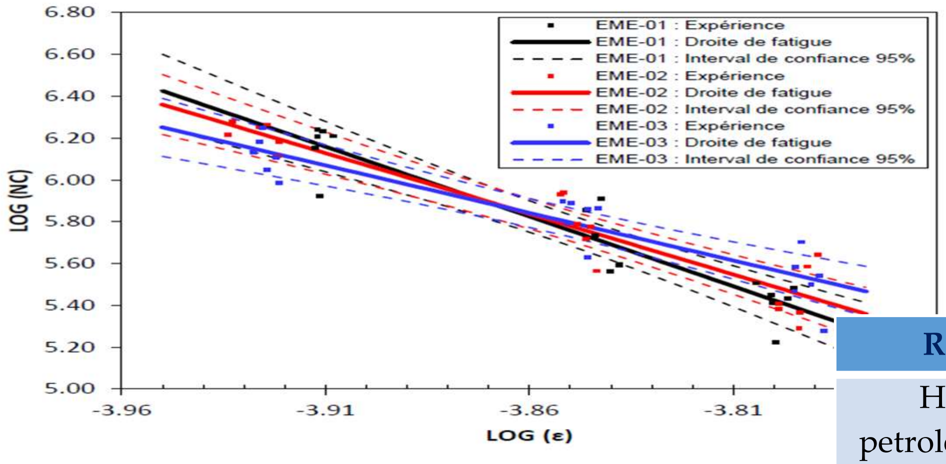
The aging evolution, expressed by (Δ_1, Δ_2) is far **more significant** for **petroleum bitumen** than the respective modified bitumen of **equivalent grade**, which **leads to the conclusion** that the Albanian natural asphaltite acts like an **aging retarder.**

A reference HMA (EME cl2, 6,3 % bitumen content) was manufactured with a petroleum hard binder 20/30, and was compared with two HMA specimens with equivalent grade binders obtained by mixing paving bitumen 50/70 + natural bitumen

Reference	Voids %	ǀ E* ǀ (15°C, 10Hz) [Mpa]	δ (15°C, 10Hz) [°C]
HMA with petroleum bitumen 20/30	1,6	17033 ± 41	12,4 ± 0,00
HMA previously modifying bitumen with natural asphalt	1,6	14655 ± 258	15,5 ±0,06
HMA adding the natural asphalt in the mixer	1,5	14435 ± 338	15,2 ± 0,13

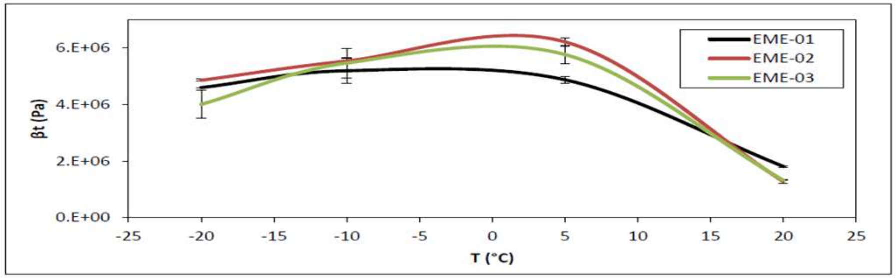
It results that the mixture produced with petroleum **bitumen 20/30** is **more rigid** than the mixtures manufactured with natural asphalt. This is **explained by the fact** that the petroleum bitumen 20/30 is **evolving more quickly** during the **manufacturing process (consistent with the** RFTOT aging tests**).** The **way of** natural asphalt **introduction, doesn't significantly** affect the **viscoelastic properties** of asphalt mixes

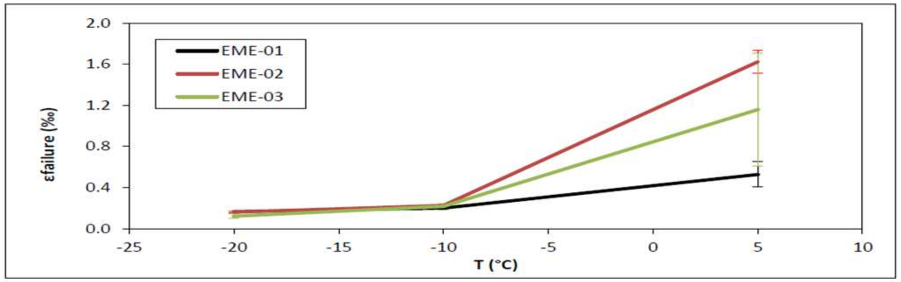
The **fatigue tests** appears to indicate that asphalt **mixtures with natural bitumen** are more performing at **high stress levels** compared to the **reference mixture** based on petroleum bitumen, which, in its turn, yields better results **at low stress** range



Reference	ε_6(m/m)	$\Delta\varepsilon_6$
HMA with petroleum bitumen 20/30	129.9 10^{-6}	3.10 * 10^{-6}
HMA previously modifying bitumen with natural asphalt	129.4 10^{-6}	3.17 * 10^{-6}
HMA adding the natural asphalt in the mixer	127.9 10^{-6}	4.10 * 10^{-6}

The **uniaxial tensile testing** results showed that HMA with **SLN** exhibit **higher resistance** to **low temperature cracking** and have **greater ductility**





Tensile strength at 5°C, 6,06 MPa vs 4,87 MPa

Deformation at failure at 5°C, 1,625 % vs 0,528 %

The thermal stress restrained specimen tests (TSRST) indicates that HMA **with SLN are less thermo-rigid** and yield **better performance** at **low temperatures** (**≈ 4,5°C lower**).

Reference	$T_{failure}$ [°C]	Standard deviation $T_{failure}$ [°C]	$\sigma_{cry,failure}$ (MPa)	Standard deviation [MPa]
HMA with petroleum bitumen 20/30	-21,4	0,27	4,523	-
HMA previously modifying bitumen with natural bitumen	-25,1	0,48	4,752	0,13
HMA adding natural bitumen in the mixer	-24,9	1,47	4,715	0,36

2

Natural asphalts as modifiers of distillation bitumen

A study was carried out by the University of Rome ***''LA SAPIENZA''*** *to characterize* ***natural bitumen*** *and evaluate their* ***contribution*** *to the modification of* ***straight-run bitumen.****The aim of this research work was* ***to characterize*** *some of the natural asphalts, most diffused commercially and to evaluate their* ***efficiency as modifiers***

Three natural asphalts were selected:

Natural asphalt	Bitumen content (%)	Asphaltènes content(%)	Penetration (à 25°C,1/10 mm)	R&B (°C)
Gilsonite	> 99	70	0	160–170
Selenizza	85-90	42*	0	115
Trinidad	53-55	33-37	1 - 4	93–98

An Iranian ***Straight Run bitumen*** (Gach Saran) with penetration **80-100,** was **added with each** of the three types of natural asphalts :

- by the percentage of **10%**
- at a minimum temperature of **150 – 180 °C**

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In order to analyze the nature of the modification, two techniques have been used:

- ***Dynamic rheological analysis***
- ***Modulated Differential Scanning Calorimetry*** (MDSC)

*The **rheological analysis** was carried out with a rotating rheometer under:*

- ***isochronal conditions,** with temperature scanning, for the assessment of viscoelastic behavior in relatively **high temperatures***
- ***isothermal conditions,** with frequency scanning, for determining the characteristics **in low temperature range***

*The trials were performed in the respective **linear viscoelastic areas for** each* sample in order to apply the temperature-frequency equivalency principle and **generate the master curves**

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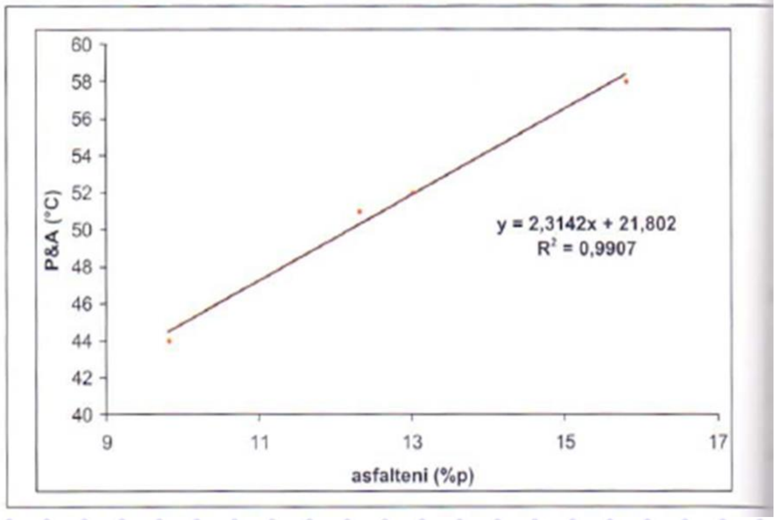
Effect on Penetration and Softening Point

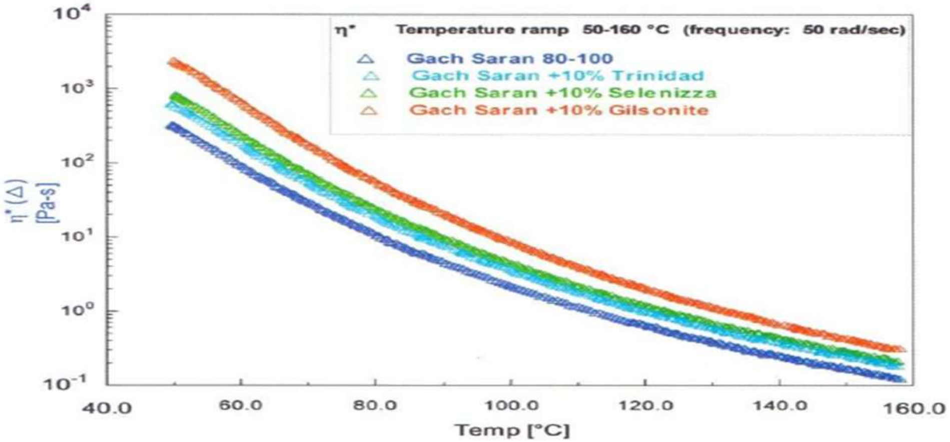
As **expected,** for the three cases, the resulting modified bitumen was characterized by **higher softening point** (R&B temperatures) and **lower penetration values**, compared to the original standard bitumen, due to the presence of **high percentages of asphaltenes** content in the natural asphalts

Type of bitumen	Penetration at 25° (1/10 mm)	R&B Temperature °C	Asphaltenes content (%)
Original bitumen	96	44	9,8
+10% Gilsonite	38	58	15,8
+10% Selenizza	67	52	13,0
+10% Trinidad	78	51	12,3



Effect on viscoelastic properties at high temperatures

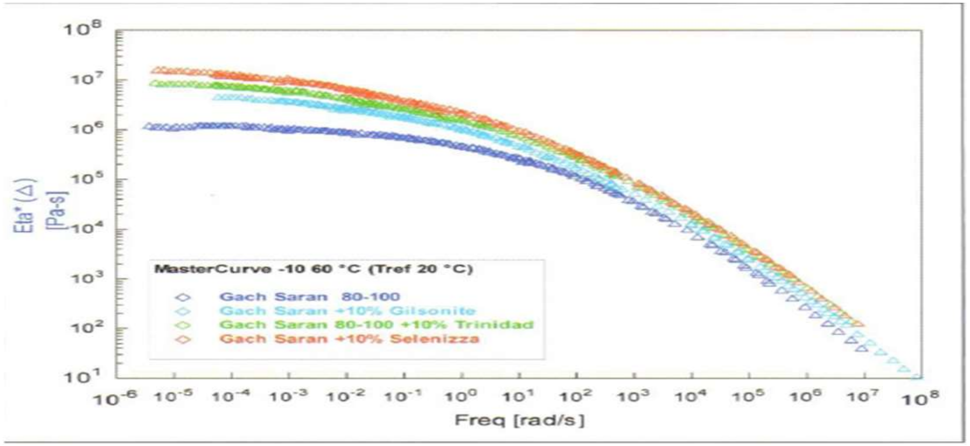
For **medium and high temperatures** (50 – 160°C), the **rheological behavior** whose softening point represent the lower limit, is not a function of the modifier quality and **depends exclusively on the asphaltenes content**



The **viscosity values increase,** the viscosity curves **shift upwards**, their shape and the slope remain unchanged and parallel for all sample types. The **modifiers don't affect the** internal **interactions** between the **asphaltene components** in the modified bitumen, which is a typical phenomenon for the **compatible additives**

Effect on viscoelastic properties at low temperatures

For the **low temperatures (10 - 60°C)**, the rheological **modifications** seem complex and are **differentiated**



Master curves η*, G′,G′′ = f(ω) drawn under reference temperatures **20°C & 60°C**. The **viscoelastic behavior** and th**e ductility** of the modified samples are **impacted by the quality of the natural bitumen** (bituminous+inorganic component). At **T=20°, inversion** of the zero shear **viscosity** $\boldsymbol{\eta_0}$ (GS) < η_0 (Gil) < η_0 (Trid < η_0 (Sln)

Modulated Differential Scanning calorimetry MDSC:

- The **samples** (7 – 10 mg), were **subjected to a modulated heating ramp** resulting from a sinusoidal temperature ripple overlaid on a linear temperature ramp:

$$dQ/dt = C_p \beta + f(T, t)$$

Temperature range: [-50 °C, + 160 °C]

- For the bitumen, the **reversing curve** ≈ 1/ C_p , is **more indicative:**

  - **vitreous transitions**
  - **fusions**

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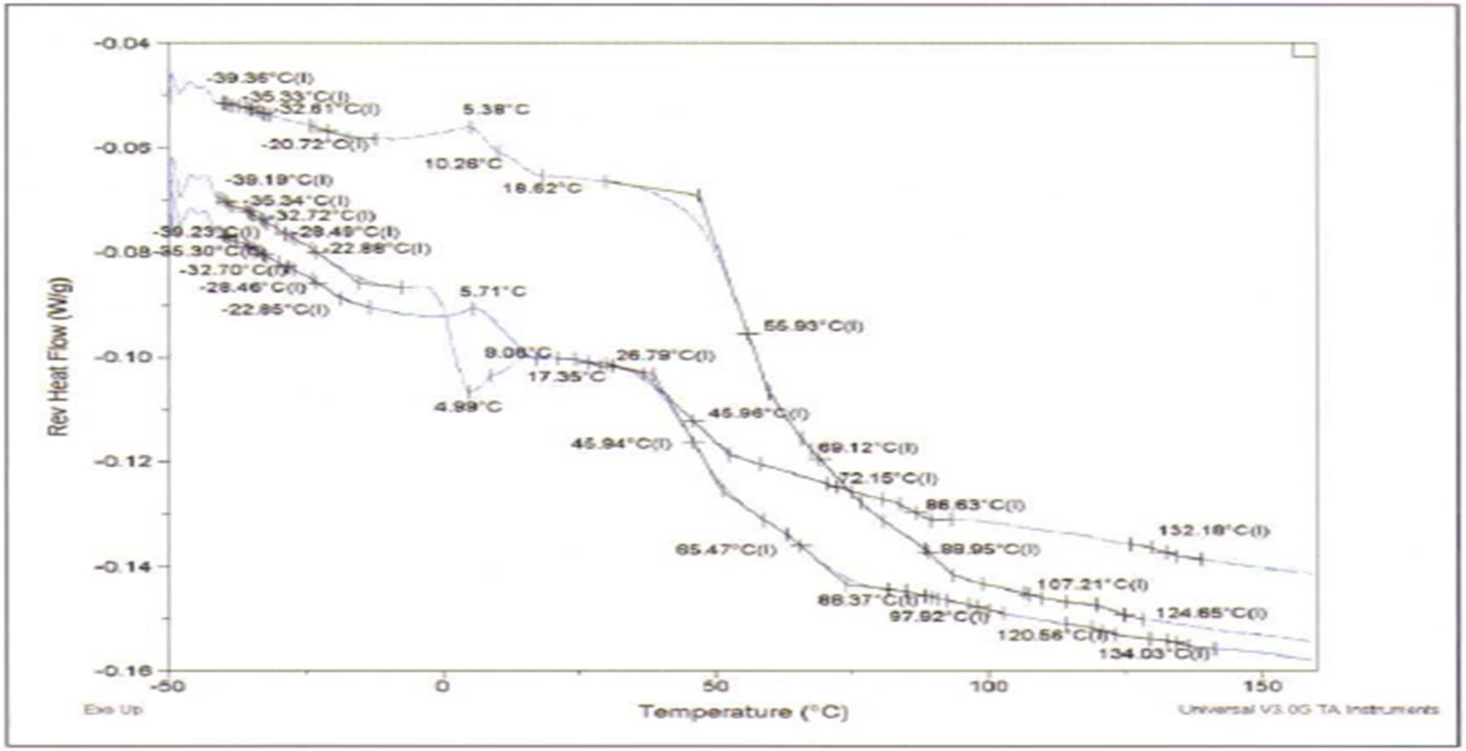
Modulated Differential Scanning calorimetry MDSC

Reversing curves of the mixed samples



The The MDSC analysis shows that the **rheological behavior** of the **petroleum bitumen** is being **modified** by the addition of natural bitumen

Trinidad & Selenizza : affect the **lower limit** of the softening range of the straight run bitumen (+55,8 °C ➔ 45,9°C) **due to the presence** of **different maltenic phases** (of lower molar mass), which **soften at lower temperatures**. The **asphaltenic phases**, result to **behave independently**. A dilution effect of the original bitumen is obtained

Gilsonite, does not act as a diluent, but **expands the softening** range to **higher temperatures**

The **modifications** operate in such a way as to **increase** the **consistency**, **the viscosity** and the **stability** of the original bitumen ➔ natural bitumen represent **an advantageous alternative** to other additives for modifying the road pavement bitumen

3

Environmental impact assessment

LIFE CYCLE ASSESSMENT

The natural albanian bitumen compared to petroleum bitumen

Worldwide economic crisis and environmental awareness have created the need for **bituminous binders** that meet **Life Cycle Assessment constraints**.

Life Cycle Assessment (LCA) **assess the durability** of the different materials evaluating the **environmental impact** during all the **stages of the product's life cycle**, from cradle to grave

More and more we need to **quantify** the **environmental impact** of construction materials and compare **potential solutions** based on **scientific data**

LIFE CYCLE ASSESSMENT

The natural albanian bitumen compared to petroleum bitumen

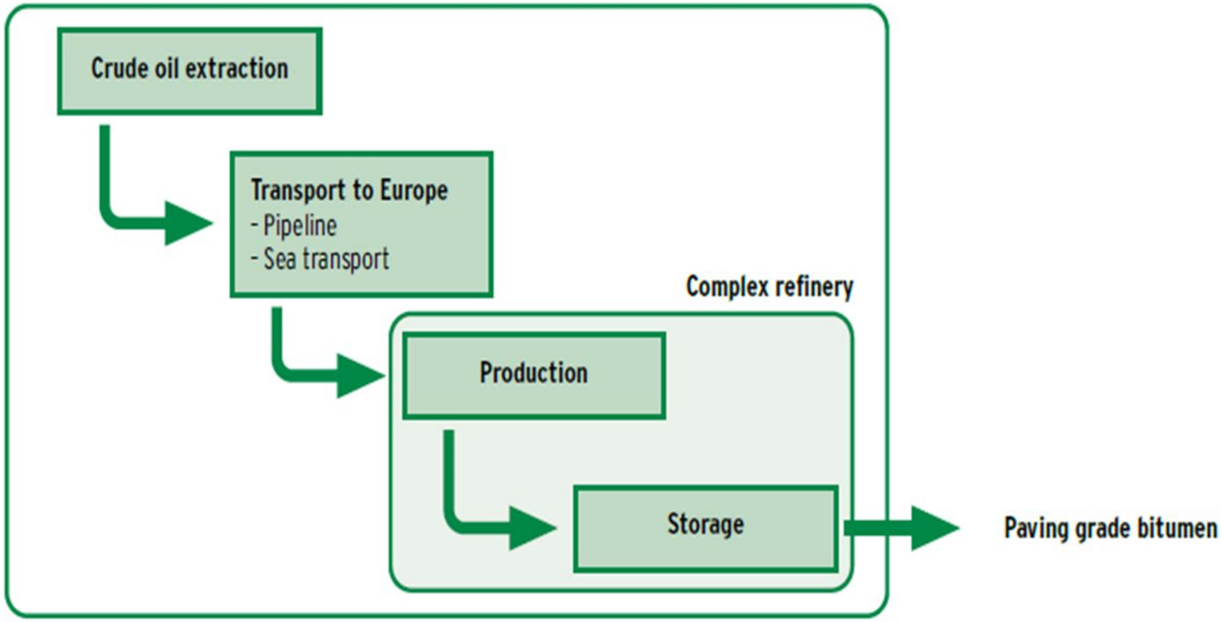
As a part of a common commitment to **sustainable development,** the **University of Rome** in cooperation with the company **Selenice Bitumi,** carried out e **research project,** whose aim was to **analyze and compare** for the first time, in terms of **energy consumption** and **CO_2 emission** between:

1. the various steps necessary to produce the **conventional bitumen from crude oil**

2. the production process of the **Albanian natural asphalt** (Selenizza)

LIFE CYCLE ASSESSMENT

Petroleum bitumen production chain (cradle to grave approach)



LIFE CYCLE ASSESSMENT

- The study was carried out **in accordance** with the guidelines of **EU regulations** (ISO 1440 and 14044) for environmental assessment, called LCA (Life Cycle Assesment) and LCI (Life Cycle Inventory), and **data have become available** from **relevant bodies** and specialized agencies such as for example, Eurobitume & EAPA (European Asphalt Pavement Association)

- The **Life Cycle Inventory** (LCI) for **straight-run bitumen,** has evaluated all the **ressources & inputs** (raw materials, electricity, fuel, etc.)

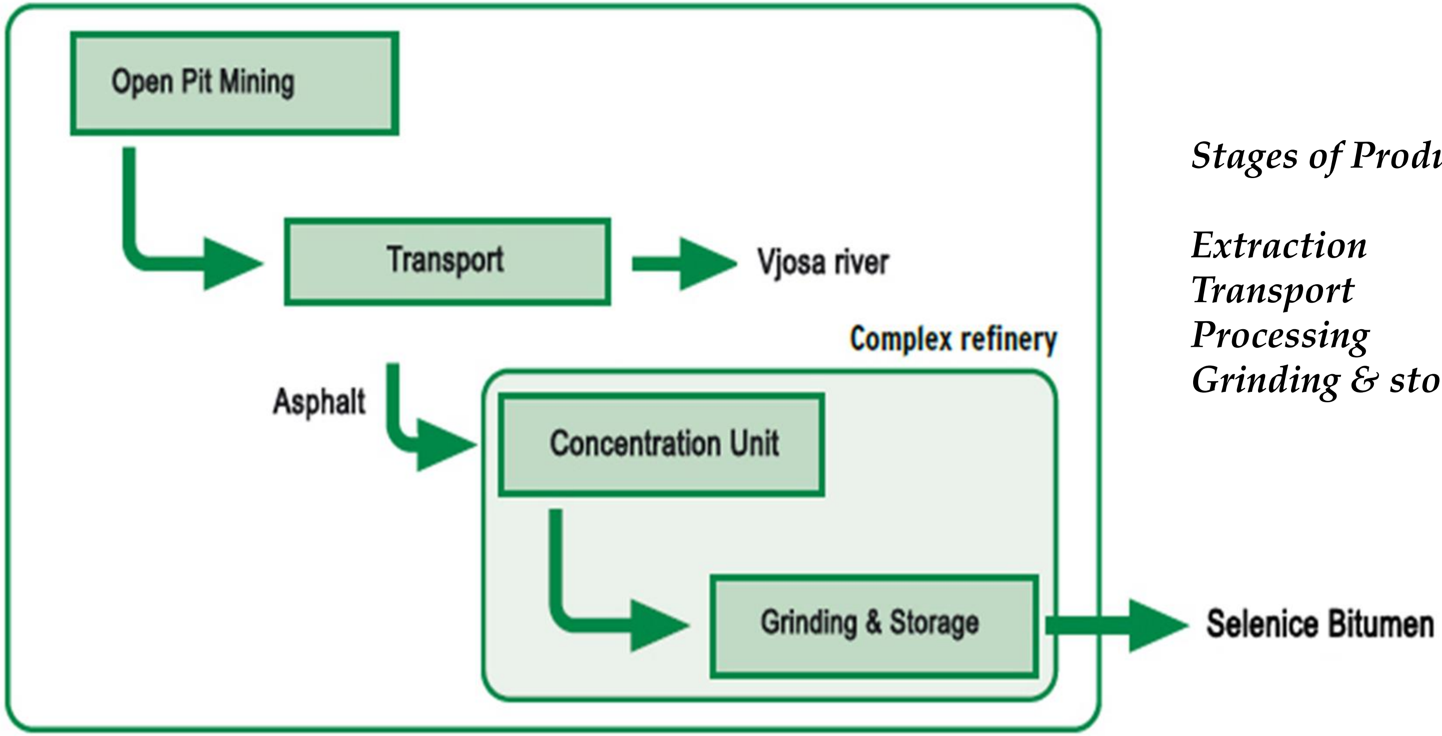
LIFE CYCLE ASSESSMENT

Deposit of Albanian natural bitumen

LIFE CYCLE ASSESSMENT

The production chain *of Albanian natural bitumen*

*The production process is **far simplier** with a direct impact on the **energy saving**; also **the transport** cost is **reduced** to minimum because the **processing unit** is located **close to** the **deposit***



Stages of Production:

Extraction
Transport
Processing
Grinding & storage

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LIFE CYCLE ASSESSMENT

- The mine of Selenice manufactures on site:
  - the **raw ore** (natural bitumen)
  - **The fuel** (bituminous coal) used for the processing of the raw ore in the heaters
  - **The residual inorganic materials are** transported and deposited close to a river in the vicinity
- In order to assess the energy consumption, has been used all the **technical documentation** of electrical equipments and mine vehicles. The **value Italo-Albanian** energy mix, has been obtained from the International Energy Agency **IEA**
- The **calorific value of the fuels,** and thus the amount of **CO_2 emissions per kg** of fuel burned, were obtained from **ENI** (Italian State Hydrocarbons Authority) data base

LIFE CYCLE ASSESSMENT

Comparing the results

Petroleum bitumen

Total	MJ/t					4,71
CO_2	g	144563	37422	7831		226 167

Natural bitumen Selenizza

Total	MJ/t					2,376
CO_2	g	59300	4500	59145		127 298

- **Selenizza's** production cycle has an **environmental impact** approximately **44% less** than the distillation bitumen
- **Energy consumption** is also reduced by **around 50%** compared to bitumen produced from crude oil

4

Implementaton examples

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High performing EME (Switzerland)

In order to respond to the **technical challenges** imposed by:

1. very **severe stresses** and strains that bituminous pavements are subject to due to the **large increase** in the number **of lorries** crossing the Swiss Alps every year
2. **very harsh climatic** conditions of the country (temperatures fluctuate between -20°C and +40°C)

Switzerland has integrated in its national standard for bituminous mixtures, the **concept of** High Modulus Asphalt Mixes **(EME)**

High performing EME (Switzerland)

- **The performance class 1** is recommended to improve the **resistance to permanent deformation** (rutting)

- **The class 2**, to improve the **fatigue resistance** of the asphalt mix layer. More difficult to reach, it includes **tough requirements** on **stiffness modulus** and **fatigue resistance** (more severe than the French one)

Specifications of Swiss standard on EME

	Méthode d'essai	AC EME 22 C1	AC EME 22 C2
Teneur en vides des éprouvettes Marshall (%)	EN 12697-8	≤ 3.0 - 5.0	≤ 1.0 - 3.0
Sensibilité à l'eau, résistance à la traction par fendage ITSR (%)	EN 12697-12	≥ 70	≥ 70
Teneur en liant en pourcentage de la masse d'enrobé (%)		≥ 4.6	≥ 5.4
Résistance à l'orniérage à 30 000 cyles et 60 °C	EN 12697-22		
Profondeur d'ornière sur une plaque de 10 cm d'épaisseur (%)		≤ 5.0	≤ 7.5
Module complexe à 15 °C/10 Hz (MPa)	EN 12697-26	≥ 11 000	≥ 14 000
Résistance à la fatigue à 10 °C/25 Hz (microdéformations)	EN 12697-24	≥ 100	≥ 135

Tableau 1
Spécifications de la norme suisse SN 640 431-1NAB pour les AC EME 22

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High performing EME (Switzerland)

To respond to this constraints, **CO.MI.BIT, an asphalt mix manufacturing cooperative,** located in Taverne (Canton Ticino), has developed a new mix design of type **AC EME 22 C2** that improves the **fatigue performance** by using **a polymer modified bitumen** all while maintaining a **high stiffness modulus** using **Selenizza®SLN** as hardening additive. In the specific case, the binder was composed of a Shell Cariphalte 25 RC **polymer modified bitumen** and **Albanian natural bitumen** Selenizza SLN

Based on the **same grading curve**, two alternatives of mix design have been tested containing different dosage levels of Selenizza, to determine its percentage for obtaining a final binder with penetration ranging between **10 to 20 dmm**

High performing EME (Switzerland)

1. First formulation (Selenizza **26%** of the total binder):

3.9% Shell Cariphalte 25 RC**+ 1.4% SLN = 5.3%**

2. Second formulation (Selenizza **29%** of the total binder):

3.9% Shell Cariphalte 25 RC**+ 1.6% SLN = 5.5%**

Composition du liant	Unité	Formule 1	Formule 2
Shell Cariphalte 25 RC	%	3,9	3,9
SLN 120	%	1,4	1,6
Teneur en liant théorique (en % de la masse d'enrobé)	%	5,3	5,5
Module complexe à 15 °C/10 Hz (EN 12697-26)	MPa	19 441	18 336
Pourcentage de vides hydrostatique	%		
Résistance à la fatigue à 10 °C/25 Hz (EN 12697-24)	Microdef	139	145
Pourcentage de vides hydrostatique	%		

Tableau 4
Résultats des essais de module et de fatigue obtenus par Shell Global Solutions

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High performing EME (Switzerland)

The obtained **modulus** and **fatigue** tests results **clearly exceed** the Swiss standard specification for the asphalt mixes AC EME 22 C2

To prevent the **cracking risk** at low temperatures, **a new job** mix formula was envisioned and then verified by **LAVOC Laboratory** at the Swiss Federal Institute of Technology Lausanne

The mix design was modified with a **less strong value** of the **stiffness modulus** while maintaining a **high level of fatigue resistance,** by increasing the binder content and introducing a lower percentage of Selenizza (**22%**), :

4.7% Shell Cariphalte 25 RC**+ 1.4% SLN = 6.1%**

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POLITECNICO MILANO 1863

High performing EME (Switzerland)

The tests performed on **extracted binder,** indicated that it belonged to a **10/20** paving grade bitumen:

Test results conducted by LAVOC, was the following (**void content** = **2.4%):**

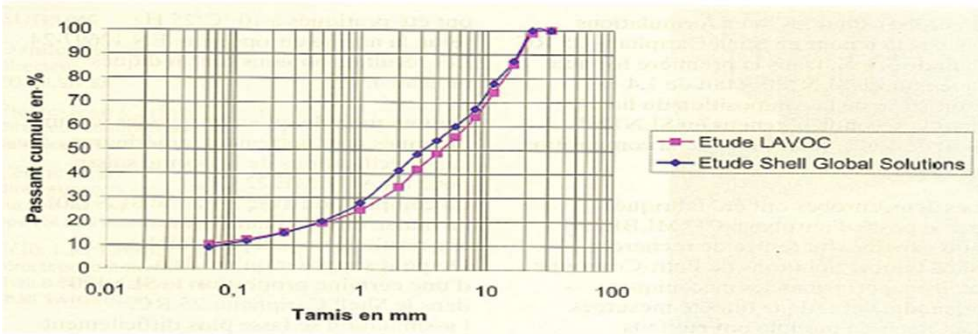


Figure 1
Courbes granulométriques des enrobés AC EME 22 testés

- **ε_6** (extrapoled) ≈ **150 µdef** **(Swiss standard ≥135 µdef)**
- **Modulus** (15°C/10 Hz) **= 15 100 MPa** **(Swiss standard ≥ 14 000 MPa)**

High performing EME (Switzerland)

➢Other mix design of type **AC EME 22 C1** were developed and validated in cooperation with **LAVOC Laboratory** at the Swiss Federal Institute of Technology Lausanne, with very good results in terms of fatigue performance and with low susceptibility to rutting

3.9 % PmB Shell Cariphalte 25 RC + **1,4%** SLN = **5.3%**

Test results:

- ❑**Richness modulus K=3.30** (standard ≥2.7)
- ❑**Rutting (at 30 000 cycles) = 1.9 %** (standard ≤5%)
- ❑ε_6 (extrapoled) ≈ **134 microdéformations** (standard ≥100 μdef)
- ❑**Modulus** (15°C/10 Hz) **= 18 016 MPa** (standard ≥ 11 000 MPa)

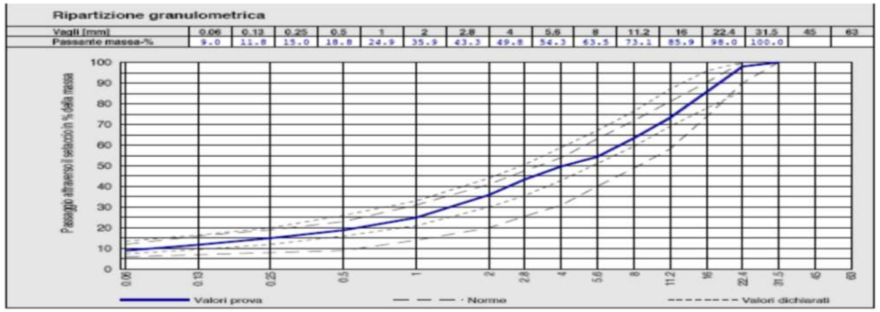
➢ The **high value of richness modulus** generates good **fatigue performances** and the asphalt mix has **low rutting susceptibility**

High performing EME (Switzerland)

It should also be noted **the use of Albanian natural bitumen** with **recycled aggregates**

Example: **AC EME 22 C2** with binder Shell B **15/20** + **10%** RA + **0.3%** SLN

Binder content = **5.34%** (4.4% Shell 15/20 + 0.64%RA + 0.3% SLN)



- **Rutting** (at 30 000 cycles) = **3.8 %** (standard ≤7.5%)
- ε_6 (extrapoled) ≈ **153** microdéformations (standard ≥130 μdef)
- **Modulus** (15°C/10 Hz) **= 14 800 MPa** (standard ≥ 14 000 Mpa)

The mixture has low rutting susceptibility **and is effective in terms of fatigue resistance.** The good behavior that was observed was also due to the addition of Selenizza

High performing EME (Switzerland)

2011 : highway bypass Bern -Switzerland

High performing EME (Switzerland)

Lugano - Switzerland

High performing EME (Switzerland)

Highway Ticino - Switzerland

High performing EME (Switzerland)

Mastic asphalt Switzerland

High performing EME (Switzerland)

2011 : Bridge Val Verzaska, Ticino - Switzerland

Highway A8 "Olimpia Odos" (Greece)

The project involved the implementation **of 375 km** highway and was designed according to the prescription of **French Standards** applied to **Greek reality and experience**.

The road structure consisted of :

- DBM (Dense Bitumen Macadam) **base course (6 cm)**
- anti-rutting **binder course AC (5 cm)**
- anti-skid TAC (thin asphalt concrete) **wearing course (2.5 cm).**

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Highway A8 “Olimpia Odos” (Greece)

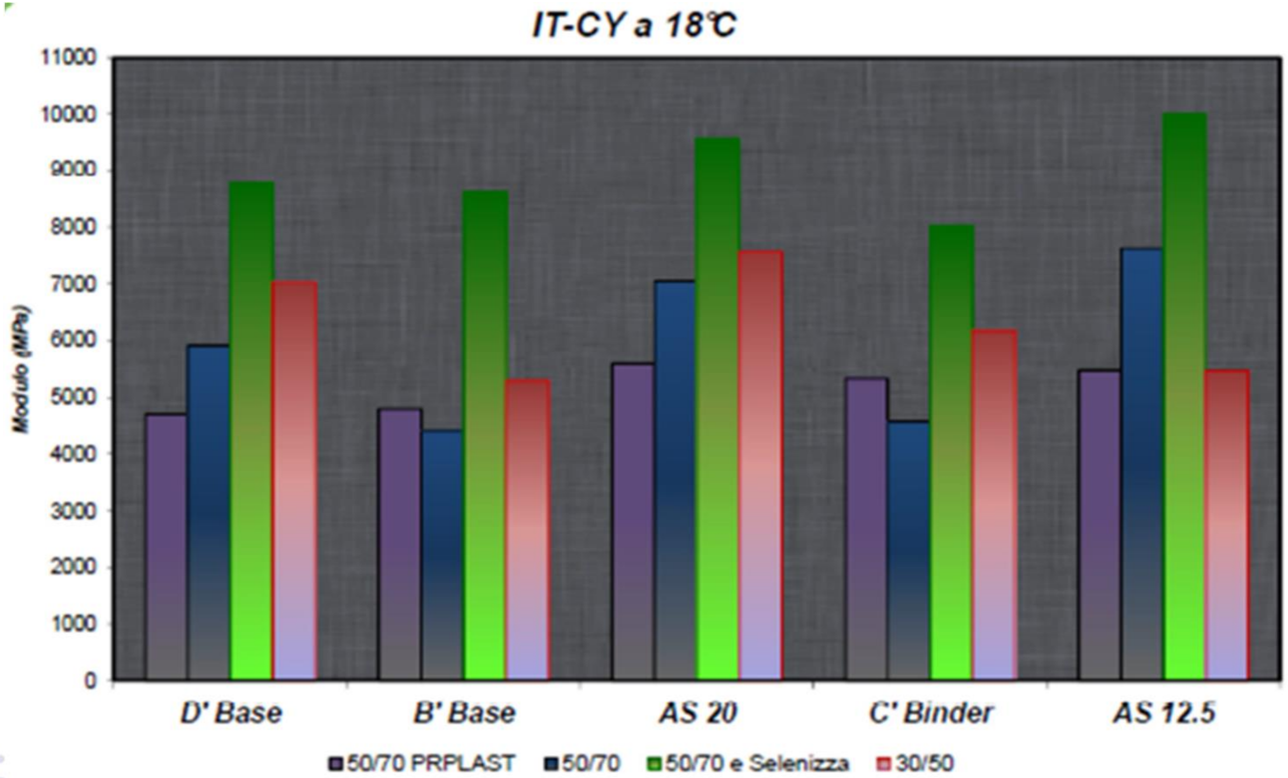
Several trial **mix designs** for the base and binder courses were tested using different kind of binders such as:

- bitumen **50/70**
- bitumen **50/70 + 8% Albanian natural bitumen Selenizza**
- bitumen **30/50**
- **PR PLAST** modified bitumen.

Highway A8 "Olimpia Odos" (Greece)

Laboratory tests results

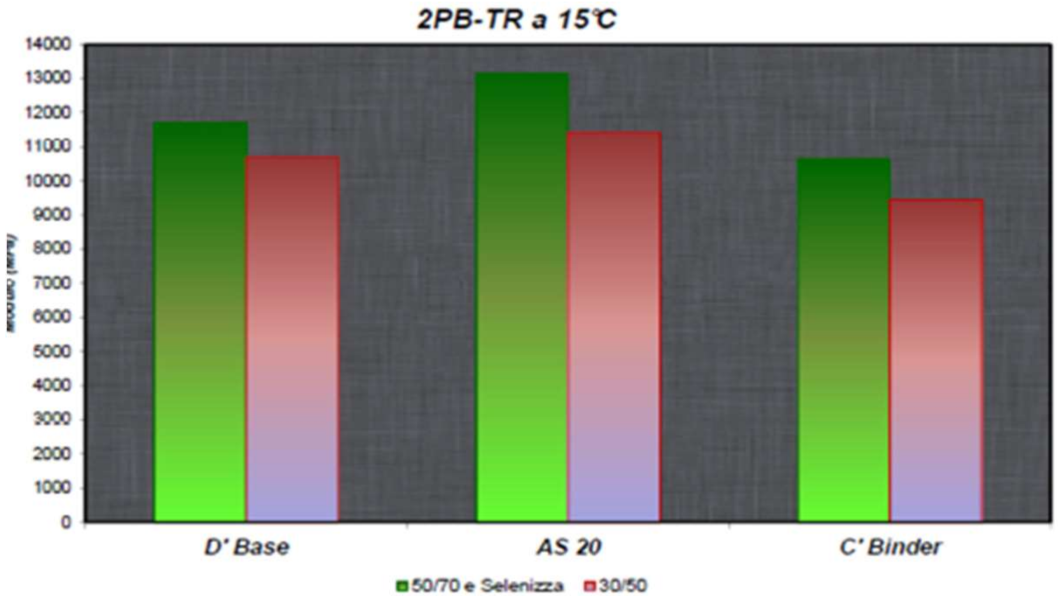
Stiffness Modulus (Indirect Tensile Test)



Highway A8 “Olimpia Odos” (Greece)

Laboratory tests results

Stiffness Modulus (Two Point Bending Test)



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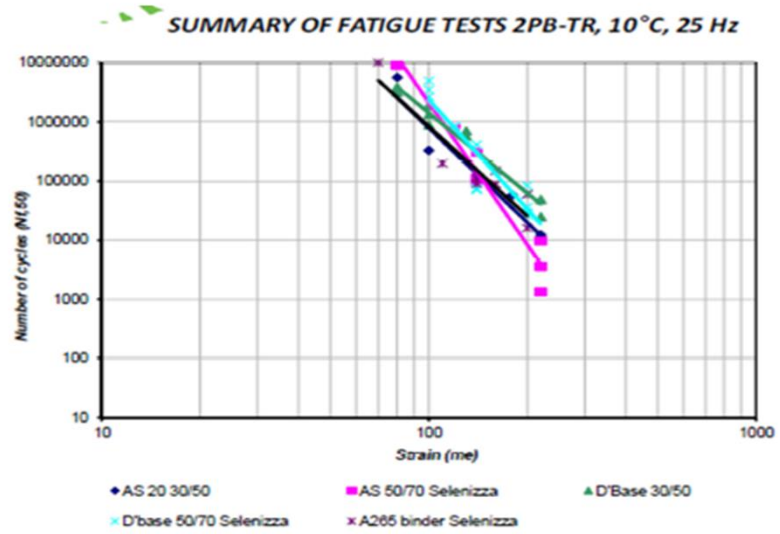
Highway A8 "Olimpia Odos" (Greece)

LABORATORY TEST RESULST FATIGUE RESISTANCE 2PB-TR



Material	*Bituminous binder*	*Fatigue ε6 10 °C, 25 Hz*	*Class asphalt mix*
STS A265 B' binder course	50/70 + 8% Selenice Pen = 39	*101.6*	DBM4
STS A 260 D' base course	30/50 Pene = 45	*108*	DBM3
STS A 260 D' base course	50/70 + 8% Selenizza Pen=39	*112*	DBM4
AS 20 base course	50/70 + 8% Selenizza Pen = 39	*110*	DBM4
AS 20 base course	30/50 Pen= 45	*95*	DBM3

	TAC	AC	DBM2	DBM3	DBM4	HDM
10°C	7200	7200	12 300	12 300	14 550	17 000
18°C	**4320**	**4320**	**7500**	**7500**	**8870**	**12200**
ε6	-	-	80	90	100	130
-1/b	-	-	5	5	5	5
SN	-	-	0,3	0,3	0,3	0,25
v	0,35	0,35	0,35	0,35	0,35	0,35
Kc	-	-	1,3	1,3	1,3	1

Highway A8 "Olimpia Odos" (Greece)

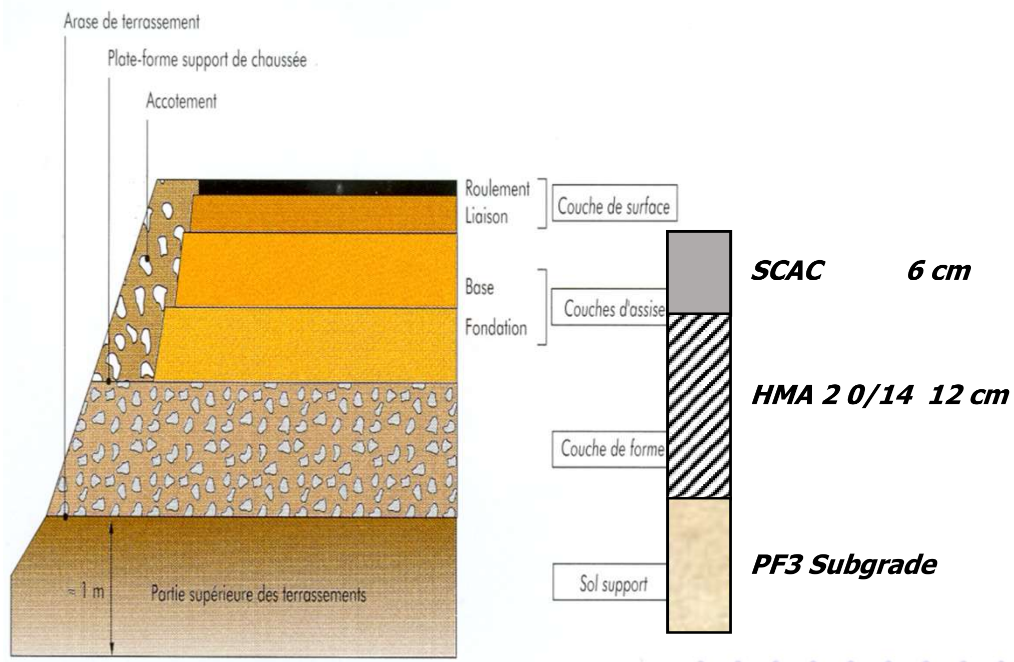
Laboratory tests on elastic modulus and fatigue showed that the binder with bitumen **50/70 + 8% Selenizza**, had higher results of **stiffness and fatigue** compared to all the other tested binders, allowing to produce an asphalt concrete that belongs to the **higher project category DBM 4**, thereby making it **possible to reduce** the road package **thickness** by at least **4 cm**

Highway A 150 (France)

PROJECT DESCRIPTION

Construction of a 17,5 km new roadway in **A 150 Highway**

In order to meet the technical specifications according to the CE standard ***NF EN 13108-1****, the project proposes using a HMA base course EB 14 ASSISE 20/30* ***or HMA (EME) 0/14 class 2***



Highway A 150 (France)

For the manufacture of the recycled hot mix asphalt, two types of binders were analyzed:

- *The basic HMA mix design*: **30% AE** (asphalt aggregates) + **20/30** penetration grade bitumen
- *Alternative studied*: **30% AE** (asphalt aggregates) + **50/70** grade bitumen **+ 1,5 %** Selenizza

Thresholds for HMA (EME) 0/14 class 2 validation

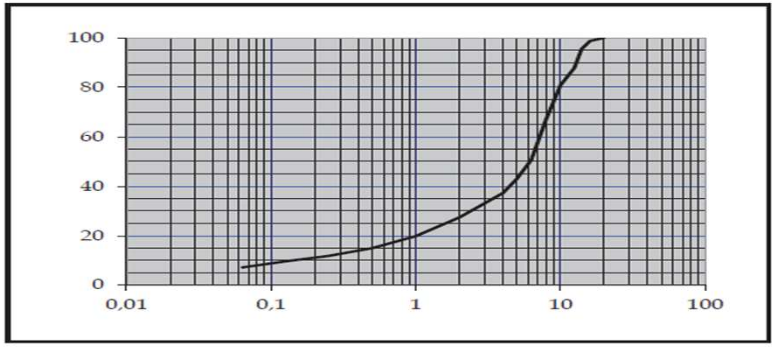
Type of asphalt mix	G.S.P. Voids content 100 gyrations %	r/R Water sensitivity	Resistance to rutting 60°C 30 000 cycles %	Modulus 15°C 10 Hz MPa	Fatigue 10^6 cycles µm/m
Test method	EN 12697-31	EN 12697-12	EN 12697-22	EN 12697-26	EN 12697-24
HMA class 2	≤ 6	≥ 0.75	≤ 7,5	≥ 14 000	≥ 130 x 10^{-6}

Highway A 150 (France)

For comparision purposes, the HMA have been made with **the same composition** of materials in terms of **particle size distribution** curve and **% of binder** used

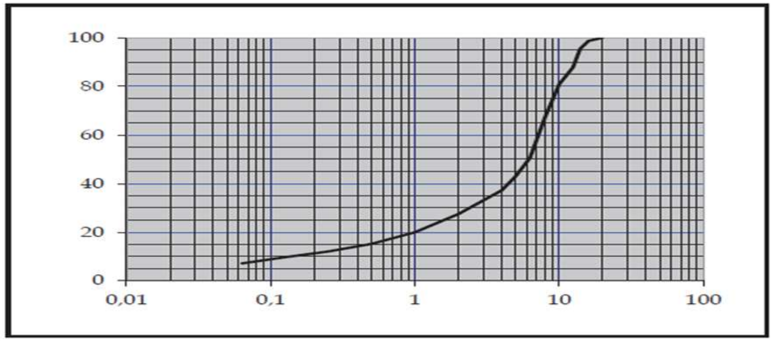
HMA(EME) 2 0/14 (30% recycl aggreg + bitume 20/30)

FORMULE			
19,5%	0/5	STEMA	
21,8%	5/8	STEMA	
12,3%	8/11	STEMA	
11,4%	11/16	STEMA	
1,4%	FILLER	CONS	
29,9%	AE		
	apport liant AE	*avec*	5,0 %TL
3,7%		20/30	
5,2%		BITUME TOTAL	



HMA(EME) 2 0/14 (30% recycl aggreg + SLN + bitume 50/70)

FORMULE			
20,4%	0/5	STEMA	
21,8%	5/8	STEMA	
12,3%	8/11	STEMA	
11,4%	11/16	STEMA	
0,3%	SLN 120	FILLER	
1,4%	FILLER	CONS	
29,9%	AE		
	apport liant AE	*avec*	5,0 %TL
2,5%		50/70	
1,50%		SLN 120	
5,2%		BITUME TOTAL	



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Highway A 150 (France)

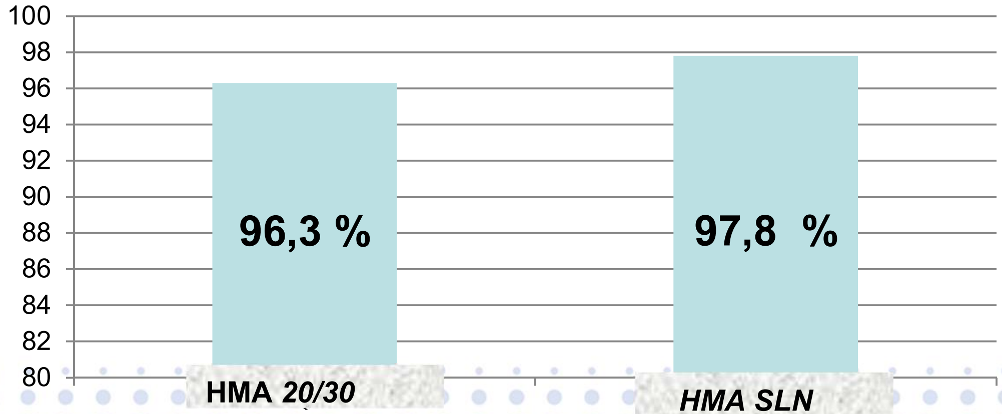
Water sensitivity

HMA 20/30

Sensibilité à l'Eau EN 12697-12 Méthode B			
COMPACITE	94,9%	*ESSAIS MECANIQUES*	
INDICE VIDES	5,1%	C_D à 18° kPa	17918
MVRG t/m³	2,767	C_W à 18° kPa	17250
MVR t/m³ *	2,545	*i*/C (%)	**96,3**
MVA t/m³	2,416	K	3,45

HMA SLN

Sensibilité à l'Eau EN 12697-12 Méthode B			
COMPACITE	95,1%	*ESSAIS MECANIQUES*	
INDICE VIDES	4,9%	C_D à 18° kPa	20623
MVRG t/m³	2,766	C_W à 18° kPa	20178
MVR t/m³ *	2,544	*i*/C (%)	**97,8**
MVA t/m³	2,418	K	3,46



The 2 specimen were compacted at the same void percentage 5%

Highway A 150 (France)

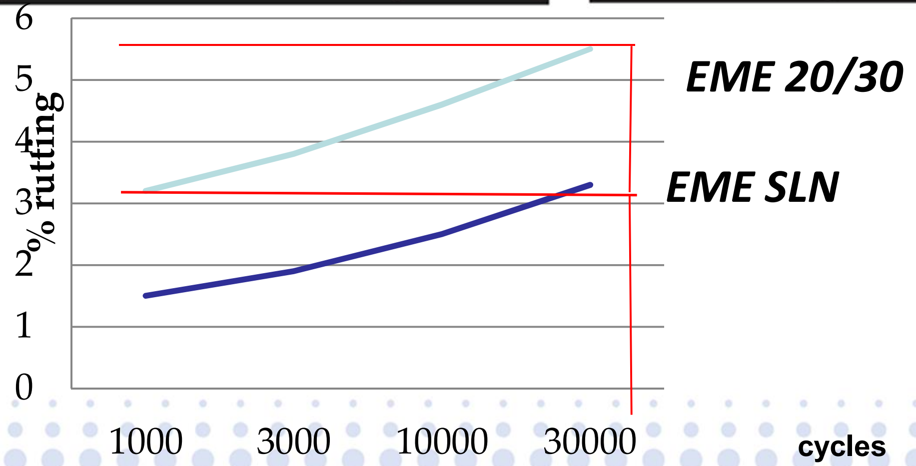
Resistance to rutting

HMA 20/30

ESSAI D'ORNIERAGE *EN 12697-22*		
% de vides des éprouvettes 4,9 %		
N Cycles	% ornière moyen	Specific.
1 000	3,2%	
3 000	3,8%	
10 000	4,6%	
30 000	5,5%	< 7,5%

HMA SLN

ESSAI D'ORNIERAGE *EN 12697-22*		
% de vides des éprouvettes 4,7 %		
N Cycles	% ornière moyen	Specific.
1 000	1,5%	
3 000	1,9%	
10 000	2,5%	
30 000	3,3%	< 7,5%

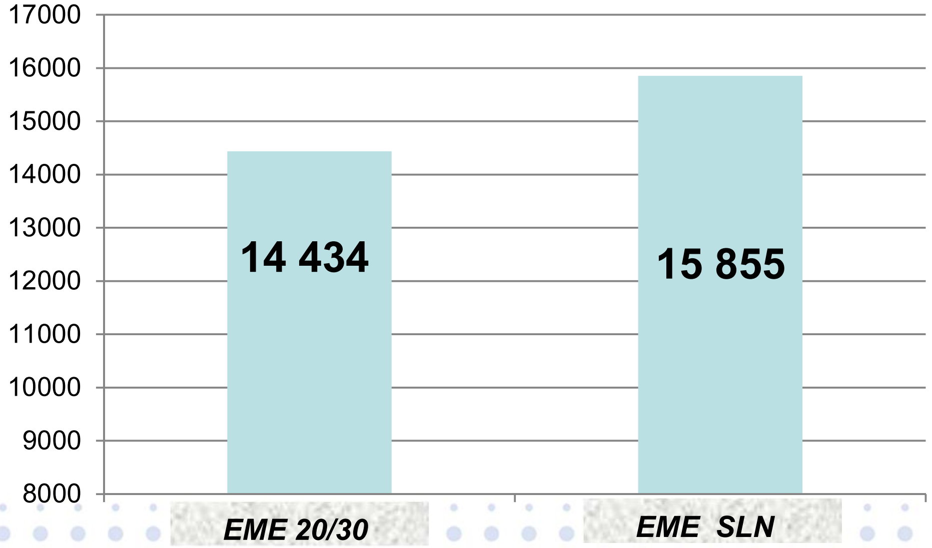


T = 60°C

Highway A 150 (France)
Elastic modulus

TRACTION INDIRECTE EN 12697-26 Annexe C	
% de vides	5,1
Module 15°C, 124ms (MPa)	14434

TRACTION INDIRECTE EN 12697-26 Annexe C	
% de vides	5,0
Module 15°C, 124ms (MPa)	15855

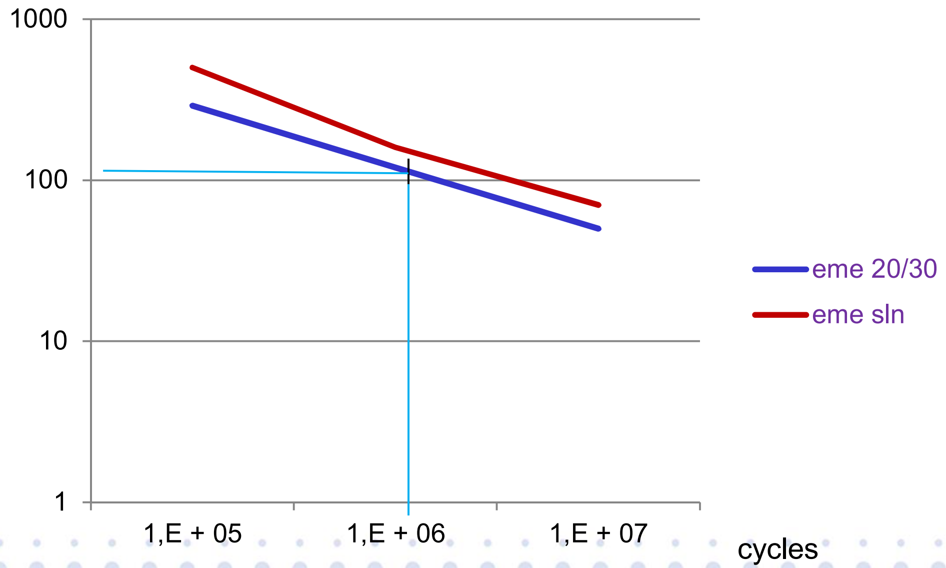


T = 15°C

Highway A 150 (France)

Fatigue

HMA 20/30	*HMA SLN*
ESSAI DE FATIGUE EN 12697-24 Annexe D	**ESSAI DE FATIGUE EN 12697-24 Annexe D**
MVA (t/m3) : 5 % de vides	MVA (t/m3) : 5,1 % de vides
Déformation relative à 10°,25Hz 134,1 µm/m	Déformation relative à 10°,25Hz 137,3 µm/m



T = 10 °C
f = 25 Hz

Highway A 150 (France)

The study results **validaded the** approach which consisits in manufacturing the recycled HMA using a straigt run bitumen **50/70 + 1,5 %** of natural bitumen *Selenizza*

5
Conclusion

- **100% compatible** with bitumen from refinery (and polymer modified bitumen)
- High performance **in modulus** & **permanent deformation**
- Better **bitumen-aggregates adhesion**
- Pavement **thickness reduction**
- Better **workability**
- **Aging retarder &** Higher **lifetime** of the pavements
- Minor **environmental impact**

Thank you for your attention!