Contribution of natural asphalts to the implementation of EME mix for cold climate

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Selenice Bitumi

Outlines

1. *Modification of petroleum road bitumen by the addition of natural asphalts*

2. *Characteristics and low temperature behaviour of SelenizzaSLN and natural asphalt modified binders*

2. *Mix design examples used in countries with vast temperature fluctuations. Selection criteria*

4. Natural bitumen: An environmentally friendly product

5. *Conclusions*

Modification of road bitumen by natural asphalts

1

Toward High Performance Asphalt Concrete (HPAC) for Cold Climates
Montreal, September 30, 2016

Characterisation of different natural asphalts

- 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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Characterisation of different natural asphalts

- *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 trails 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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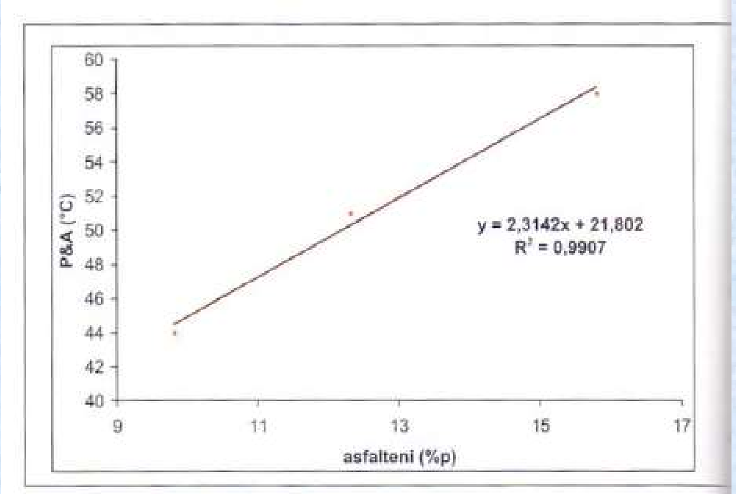
Characterisation of different natural asphalts

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



Relationship between aspaltene content and R&B

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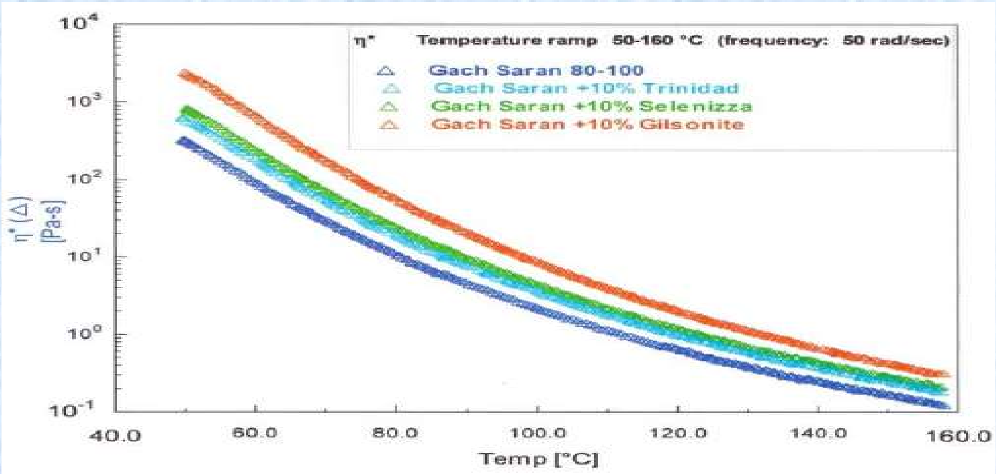
Characterisation of different natural asphalts

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**

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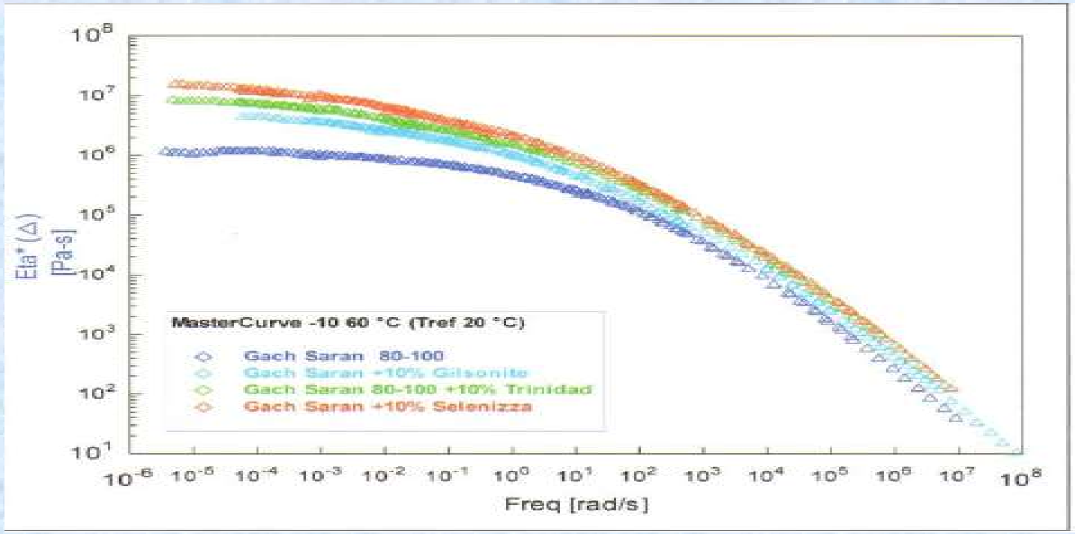
Characterisation of different natural asphalts

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 the **ductility** of the modified samples are **impacted by the quality of the natural bitumen** (bituminous+i**norganic** component). At **T=20°, inversion** of the zero shear **viscosity** η_0 (GS) < η_0 (Gil) < η_0 (Trid < η_0 (Sln)

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Characterisation of different natural asphalts

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]

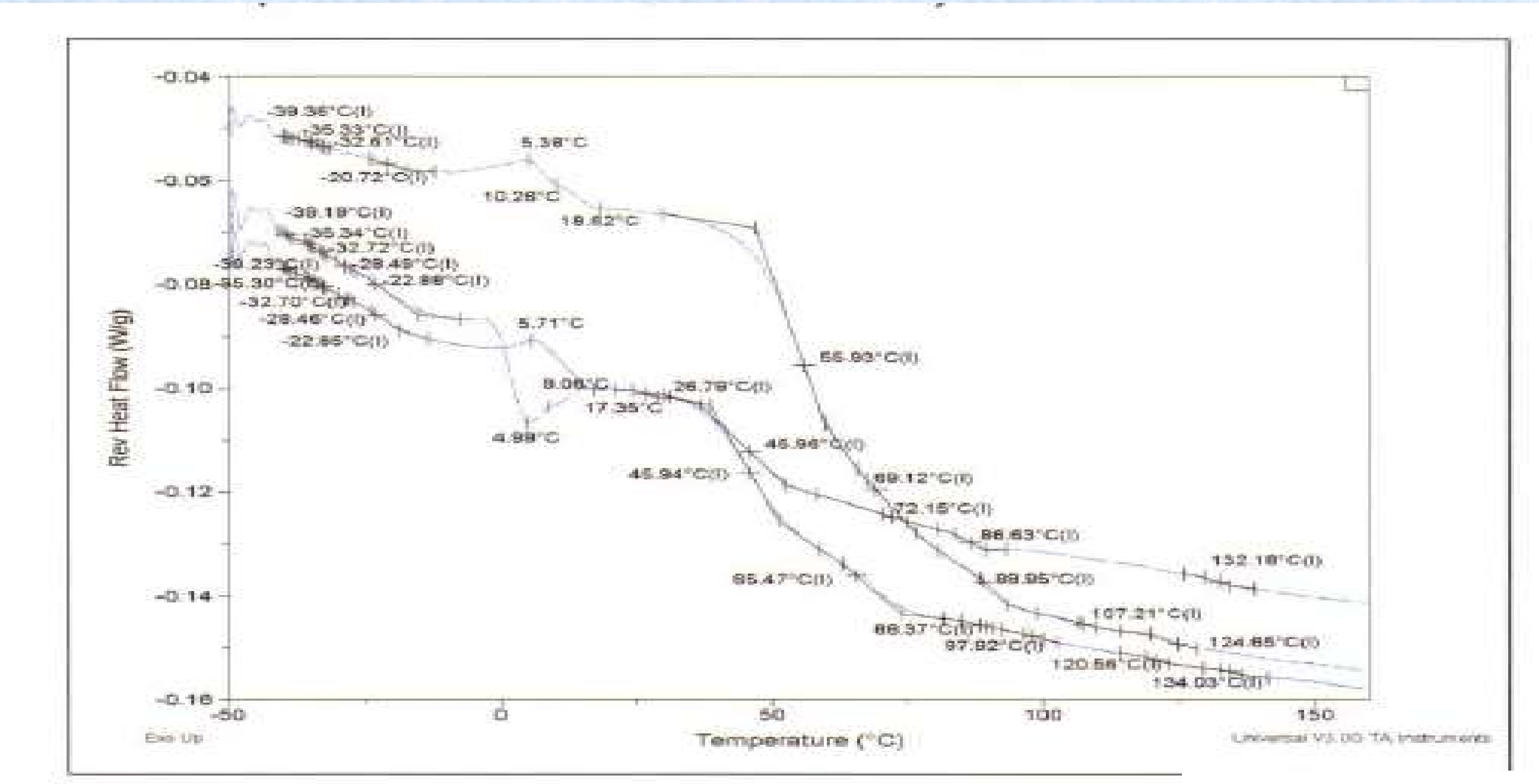
- For the bitumen, the **reversing curve** ≈ 1/ C_p , is **more indicative:**

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

Characterisation of different natural asphalts

Modulated Differential Scanning calorimetry MDSC

Reversing curves of the mixed samples



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Characterisation of different natural asphalts

Modulated Differential Scanning calorimetry MDSC:

- 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

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Characterization of Selenizza ®SLN 2

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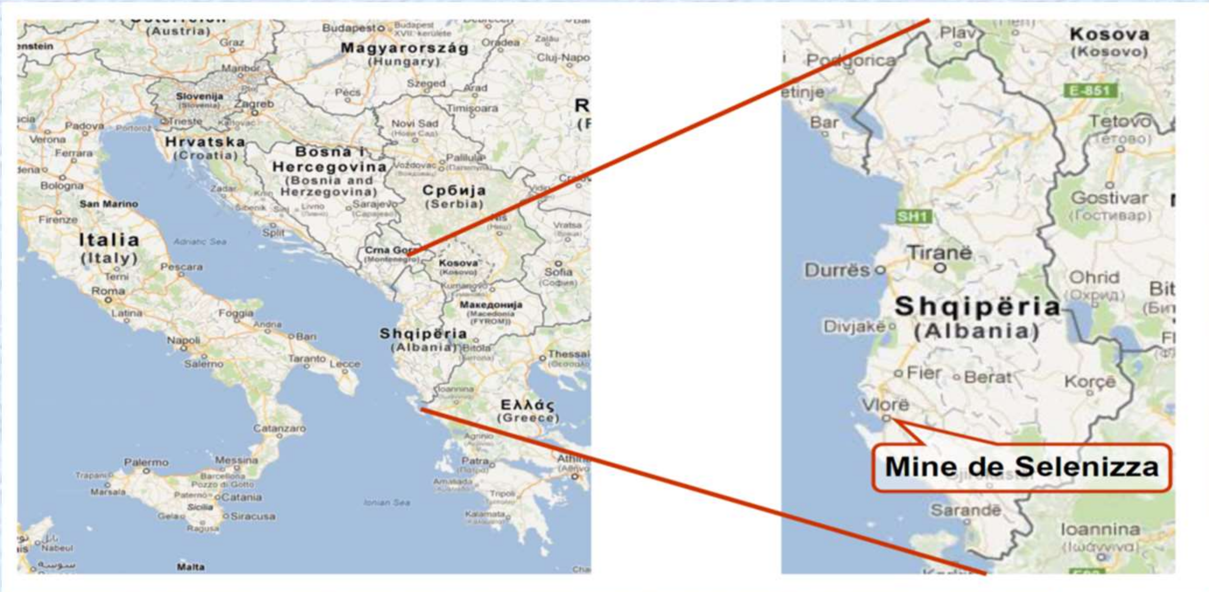
Montreal, September 30, 2016

Characterisation of natural bitumen Selenizza®SLN

- The mine of **Selenice** is located in southeast **Albania. It has been mentioned** since ancient times **by Aristotle** and has been actively exploited by the Romans. After centuries of silence, in **1868,** The French **geologist Coquand** published for the first time a **geological description of** the albanian bitumen deposit. The ottoman government transferred the mine operating rights to the French (1871), followed by the **Italains** (1919-1943). After the Second World War, the mine was exploited by the Albanian government.

Since 2001, the mine is managed and operated by the **French company KLP Industries** and the modern bitumen production, with open pit mine operations, has witnessed a remarkable progress.



➢

Principal characteristics of SelenizzaSLN

Penetration at 25°C (1/10 mm)	EN 1426	≤ 2
Softening point temperature (R&B °C)	EN 1427	≤ 120
Acidity Index (mg KOH/g)	EN 14104	3,5
Density at 20°C (g/cm^3)	EN ISO 3838	1,16
Asphaltene content (% wt)	ASTM D2007-11	> 50
Mass loss at 163°C, 5 hours (%)	EN 13303	0,08

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Characterization of natural bitumen Selenizza®SLN

- 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…

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Characterization of natural bitumen Selenizza®SLN

- The analysis of **physico-chemical properties** of natural bitumen Selenizza 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 fractional composition – 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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Low temperature behaviour

Evolution of the glass transition temperature of the modified bitumen versus le % of Selenizza

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

- **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

- 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, which indicates **a better resistance** of natural bitumen **to brittle fracture**

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Aging effect of natural 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)

Selenizza®SLN *: ageing retarder*

Penetration and TR&B of bitumen before and after ageing

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**

Aging is reflected in an **increase** of softening point temperature and **decrease** of penetration. These changes (Δ_1, Δ_2) of modified bitumen, are at a **lesser degree compared to the changes** (Δ_1, Δ_2) of petroleum bitumen

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Selenizza: ralentisseur du vieillissement

- The **ageing effect** and **thermal fatigue** are coupled. Low temperature fatigue cracking and ageing, **are cumulative** in effect **by amplifying** the **thermal stress** generated during **cooling.** Consequently, it is reasonable to assume that the use of binders **modified with Selenizza**, offers **an advantage** in terms of **behavior** of asphalt mixes **at low temperatures** compared with equivalent petroleum paving grade bitumen

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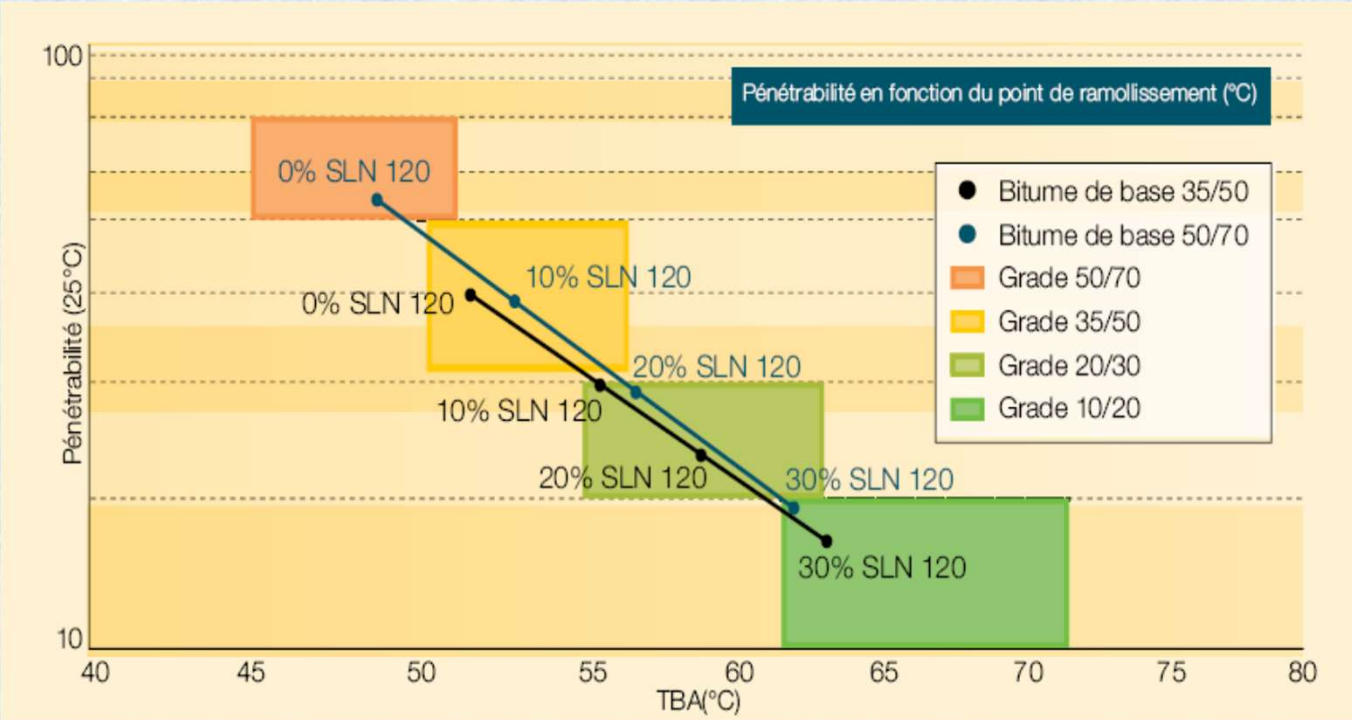
Total binder modification

- The analysis of **physical-chemical** properties and **mechanical behaviour** of natural bitumen Selenizza, showed that **structurally,** its organic phase **can be compared to petroleum bitumen**, but with mais with different propotions of maltenic and asphaltenic fractions, making it **100% compatible** with **any type of road bitumen**



- Depending on the added quantity of Selenizza and on the base bitumen, it is possible to **obtain precise penetration** and/or **R&B softening point** value of the resulting binder

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Low-temperature fracture

EME-01: with **petroleum bitumen 20/30, EME-02** : bitumen **50/70** previously modified by **SLN, EME-03:** addition of **Selenizza into the mixer**

The results presented in the figure show that the **EME-01** is more **thermo-rigid** compared to the **EME with natural bitumen**

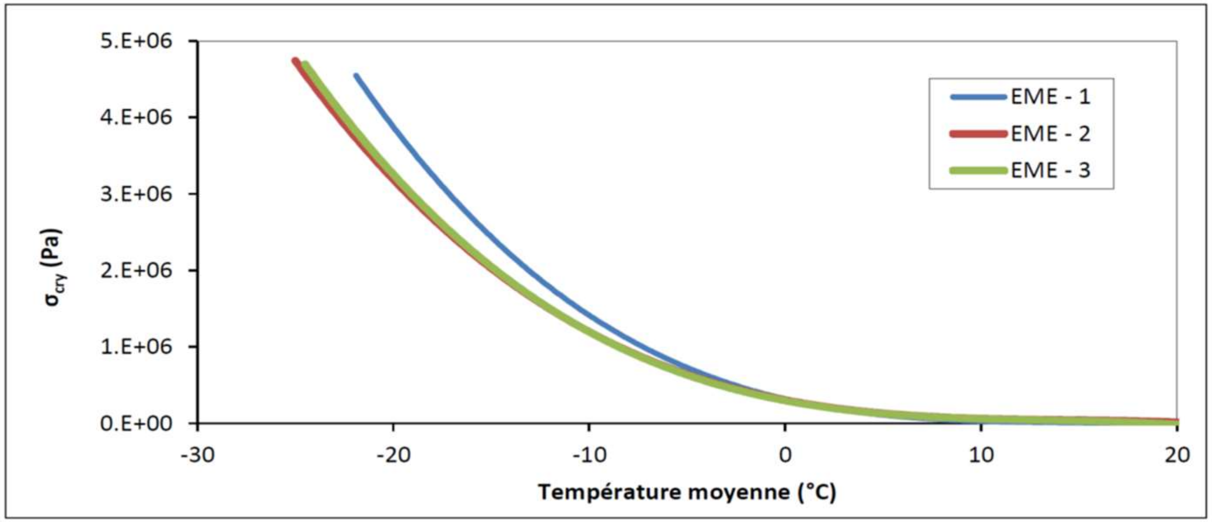

Figure 94 : Contraintes cryogéniques déterminées par l'essai de retrait empêché.

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Low-temperature fracture

The **EME with natural bitumen Selenizza** have **better low temperature** performance **compared** to the **EME** manufactured with hard petroleum **bitumen of equivalent grade**

Temperatures and thermal stress failure

Référence	$T_{failure}$ (°C)	Ecart type $T_{failure}$ (°C)	$\sigma_{cry,failure}$ (MPa)	Ecart type $\sigma_{cry,failure}$ (MPa)
EME-01	-21,4	0,27	4,523	-
EME-02	-25,1	0,48	4,752	0,13
EME-03	-24,9	1,47	4,715	0,36

The **EME-02 et EME-03** manufactured with Selenizza **are vey close to an EME class 2**, the best performing material according to **European Standards**

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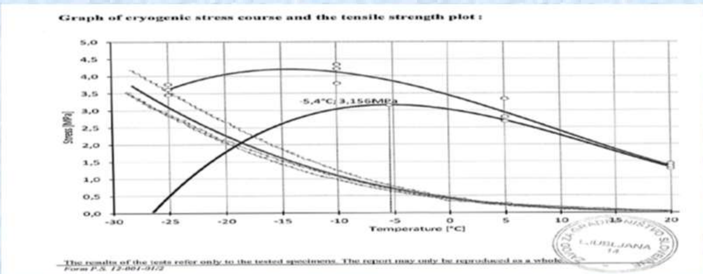
Low-temperature fracture

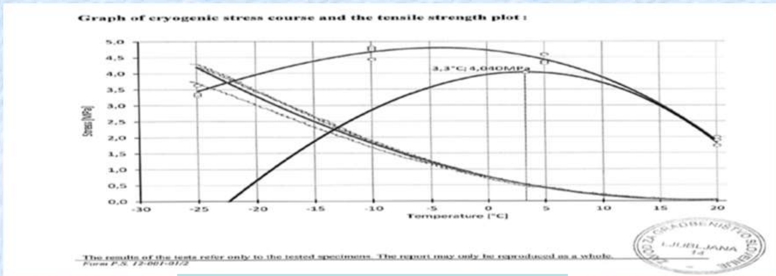
➢ The Laboratory for Asphalts and Bitumen-Based of the Slovenian National Building Institute (**ZAG), conducted TSRST comparative tests on base course asphalt mixture specimen AC 22 with 50/70 pen bitumen,** and the **same mix design** with 50/70 pen bitumen **modified with SelenizzaSLN**

The tensile strength and cryogenic curves resulting from the tests showed that Selenizza brings **some rigidity** (with Selenizza, the cirves are shifted to the right, toward positive temperaturs). At **T= 3,3 °C**, the asphalt mixture with Selenizza is subjected to a higher tensile strength **4,04 MPa**, as compared with the tensile strength **3,156 MPa at T= - 5,4 °C**, for the classical asphalt mixture

Graph of cryogenic stress course and the tensile strength plot



Binder 50/70



Binder 50/70 + SLN

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Low-temperature fracture

- The TSRST tests show that the addition of Selenizza **has little influence on the** low temperature fracture resistance of the asphalt mixture (**-25°,3** versus **-28°,4**)

Test results summary :

Failure temperature at TSRST	$T_{failure}$	-28,4°C
Maximum tensile strength reserve	$\Delta\beta_{t,max}$	3,156MPa
Temperature at $\Delta\beta_{t,max}$	$T(\Delta\beta_{t,max})$	-5,4°C

Test results summary :

Failure temperature at TSRST	$T_{failure}$	-25,3°C
Maximum tensile strength reserve	$\Delta\beta_{t,max}$	4,040MPa
Temperature at $\Delta\beta_{t,max}$	$T(\Delta\beta_{t,max})$	3,3°C

Binder 50/70

Binder 50/70 + SLN

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Combine the benefits of **polymer modified bitumen** with the natural bitumen ***SelenizzaSLN***

- Generally speaking, studies on petroleum bitumen modified with natural bitumen show that the latter **improve** the behaviour at **high temperatures** (in particular the **rutting resistance**) and **deteriorate the one at low temperatures.**

- The **combination** of **natural bitumen** with **polymers** offers an **attractive solution** on a **technical** and on an **economic level**. **A part of SBS** may **be replaced** by natural bitumen in order to **reduce the cost** of asphalt mixture production. Also, according to some authors, the replacement of SBS by natural asphalt, **increases the workability,** which could allow the reduction of the **compaction energy.**

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EME mix design examples. Selection criteria

3

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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- 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 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**

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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

- **The addition of 29%** Selenizza gives poorer results. An explanation of this could be that beyond a certain proportion of Selenizza, **the assimilation becomes more difficult** and would not contribute to increasing the asphalt mix performances

- 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

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High performing EME (Switzerland)

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

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

  Richness modulus **K= 3.74**

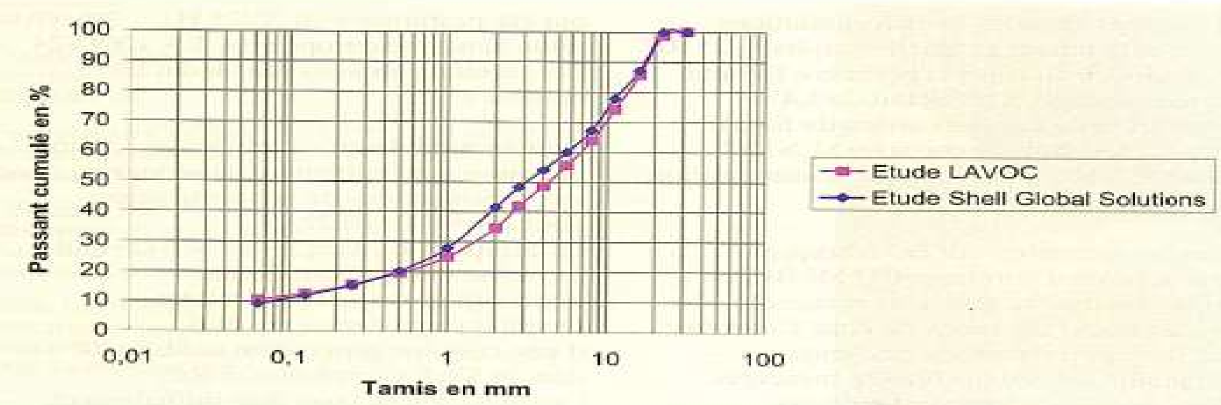

Figure 1
Courbes granulométriques des enrobés AC EME 22 testés

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

- **penetration** = **13 dmm**
- **TR&B = 86,7°C**

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

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

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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**

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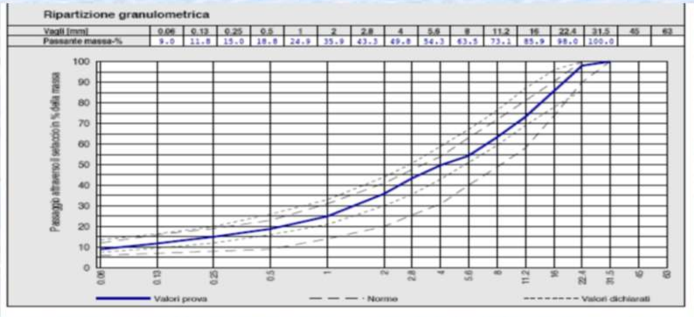
- **It should also be noted the use of Selenizza with the recycled aggregates**

  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

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High performing EME (Switzerland)

- In Switzerland, after 10 years' **service with harsh winters,** in the various road construction projects where Selenizza was used for the manufacture of high performing EME , **no thermal cracks were found** confirming the relevance of these EME mix designs that have led to **high mechanical performances**

- These results **confirm the potential** for successfully **combining** the benefits of **polymer modified bitumen** and of natural bitumen **Selenizza SLN**

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Construction sites with Selenizza®SLN

2011 : Bridge Val Verzaska, Ticino - Switzerland

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Construction sites with Selenizza®SLN

Lugano - Switzerland

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Construction sites with Selenizza®SLN

Mastic asphalt Switzerland

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Construction sites with Selenizza®SLN

Highway Ticino - Switzerland

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Construction sites with Selenizza®SLN

2011 : highway bypass Bern -Switzerland

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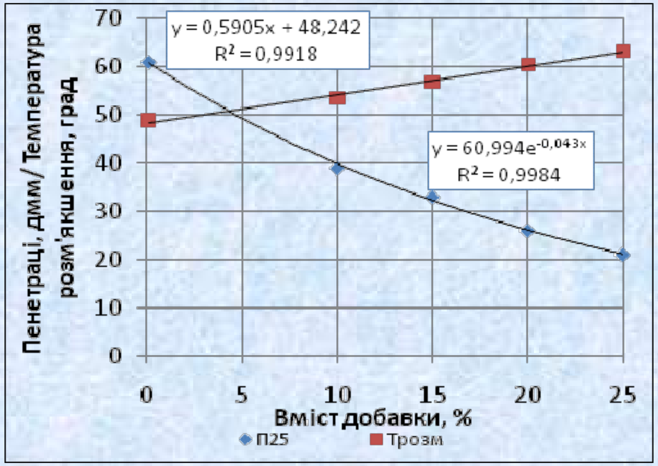
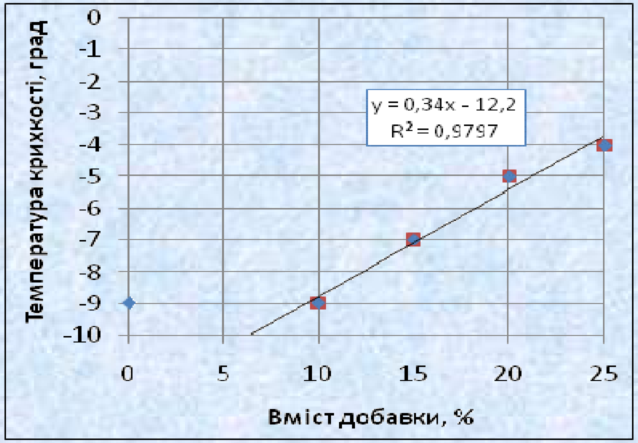
High performing asphalt mixes in Ukraine

In Ukraine, SelenizzaSLN was l**egalized** as **construction material.** It as been classified as a bitumen modifier for asphalt mixes that should be inserted to a proportion of **4-12% by mass of the base bitumen.** **The National Technical University of Ukraine** has analyzed the properties of Selenizza aiming to determine its compatibility with the Ukrainian bitumen (**60/90 grade bitumen)** and with those of **bordering foreign countries.**



***T*R&B and Penetration** *Modification*
of BND 60/90** bitumen with **the % of Selenizza



Fraass Fragility Point Modification of BND 60/90 with the % of Selenizza

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High performing asphalt mixes in Ukraine

The analysis showed that the addition of Selenizza up to **10%, does not affect the Fraas temperature of** 60/90 bitumen. Above this %, a **proportional increase** of the Fraas point with the % of Selenizza was observed

SLN [%]	0	10	15	20	25
Fraas T [°C]	-9	-9	-7	-5	-4

In general, the percentage of SelenizzaSLN used in Ukraine varied from **4%** to **16%** (mainly **5%** and **8%**), in different **heavy traffic** areas operating under **harsh climatic conditions with temperatures fluctuating between -30** to **+ 30°C**

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High performing asphalt mixes in Ukraine

- Highway **Kiev – Kovel,** in the **western part of Ukraine**, surface paving SMA -20, 8cm base course & 8cm binder course, on 3 segments with a total length of approximately **5 km**

with Selenizza

with SBS

After 3 years' service, the road is still in a very good condition !!!

In the middle of the highway constructed using Selenizza, on a small section, **for comparision purposes,** was used a **Kraton modified binder.** The asphalt roadway surface with Selenizza is **smoother** and is more **black in color** compared to the segment where Kraton modified binder was used

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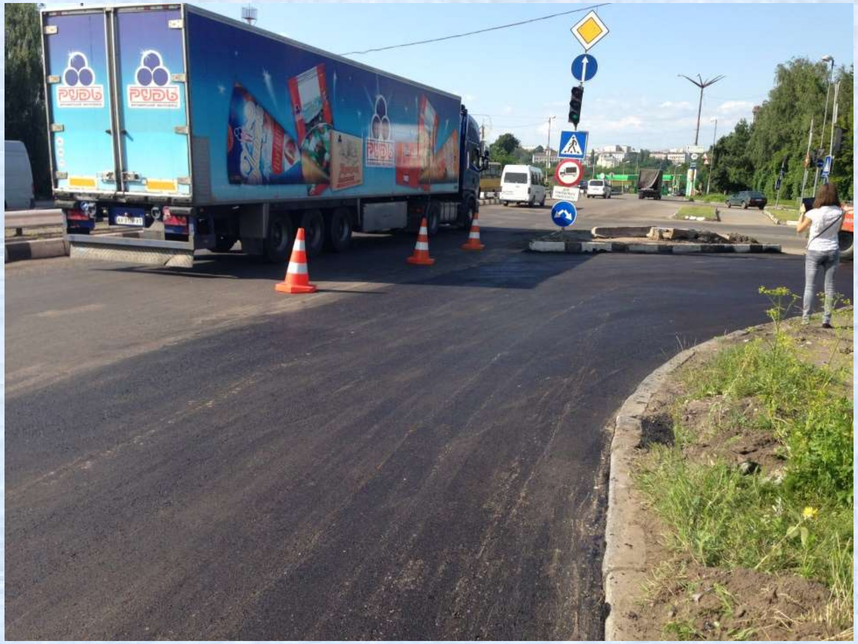
High performing asphalt mixes in Ukraine

Zhitomir, 70 Km west of **Kiev**

Before



After

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High performing asphalt mixes in Ukraine

National highway Mykolaiv (Ukraine)

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High performing asphalt mixes in Ukraine

Kiev

SMA with 6 % Selenizza

Heavy traffic highway interchange entering Kiev

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High performing asphalt mixes in Ukraine

Ring road around Kiev (Ukraine)

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High performing asphalt mixes in Ukraine

Helicopter landing pad in the downtown Kiev near Parliament building, constructed with asphalt mix using **6,5% Selenizza**

After **5 years' service**, it resulted that the use of SelenizzaSLN was very effective, in general there were no evidence of rutting or other **FRAAS breaking** point related **damages**. The resistance to **permanent deformation increased** by a factor of **1,5** t

An environmentally friendly bitumen

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LIFE CYCLE ASSESSMENT

SELENIZZA 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 de differents 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**

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LIFE CYCLE ASSESSMENT
SELENIZZA 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)

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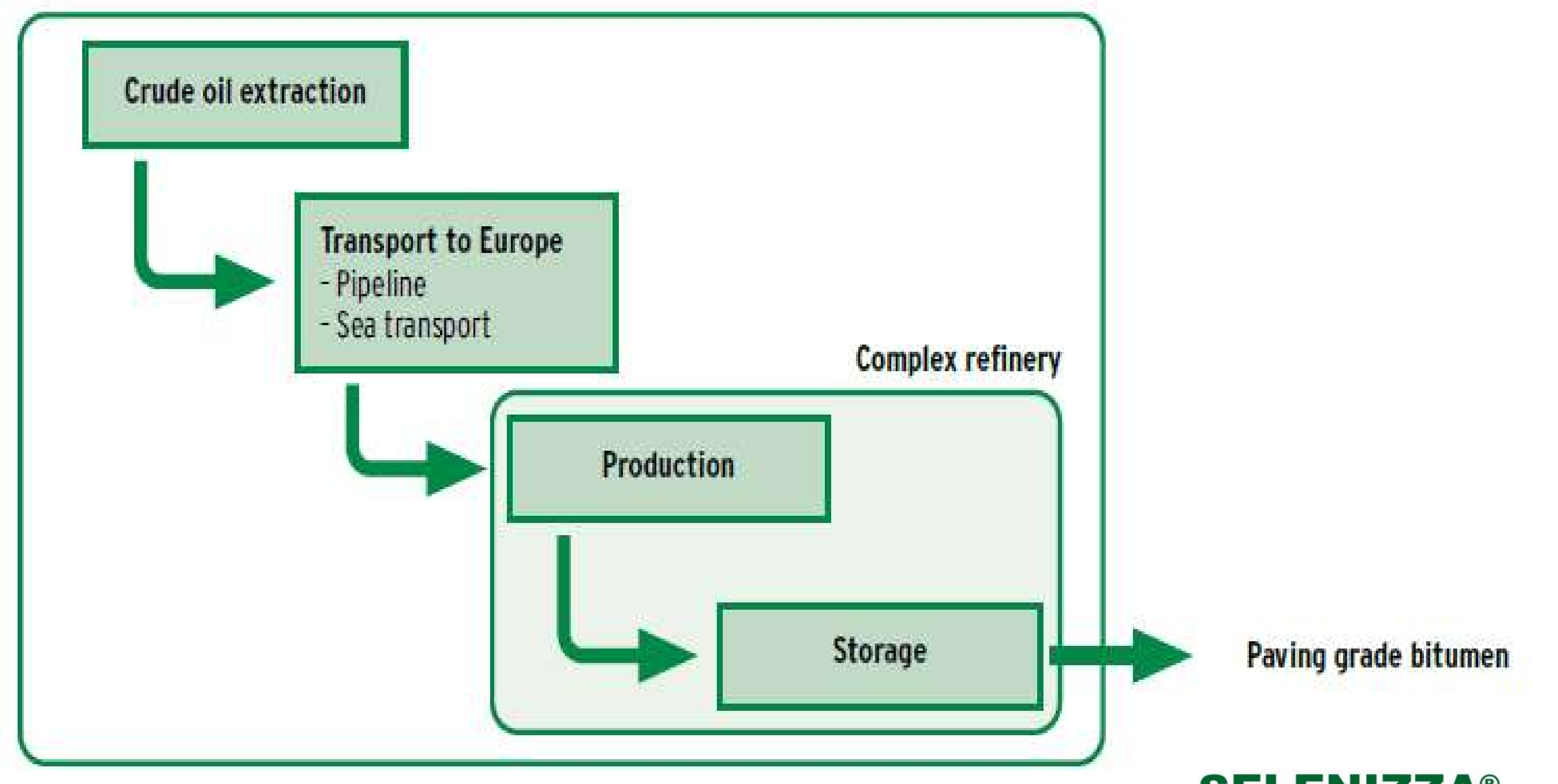
LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

Petroleum bitumen production chain (cradle to grave approach)



SELENIZZA® NATURAL BITUMEN

LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

- 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.)

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LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

Consommation d'énergie et emisssion CO_2 pour les bitumes routiers de distillation

Production 1 tonne bitume (processus avec infrastructure)	unité	Extraction pétrole brut	Transport	Raffinage	Stockage	Total
Matière première						
Pétrole brut	kg	1000				1000
Consommation de ressources énergétiques						
Gaz naturel	MJ/t	2,196		0,855	0,001	3,061
Pétrole brut	MJ/t		0,588	0,404	0,096	1,088
Electricité	MJ/t					0,561
Total	MJ/t					**4,71**
Emissions dans l'air						
CO_2	g	144563	37422	7831		**226167**

LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

Deposit of natural bitumen Selenizza

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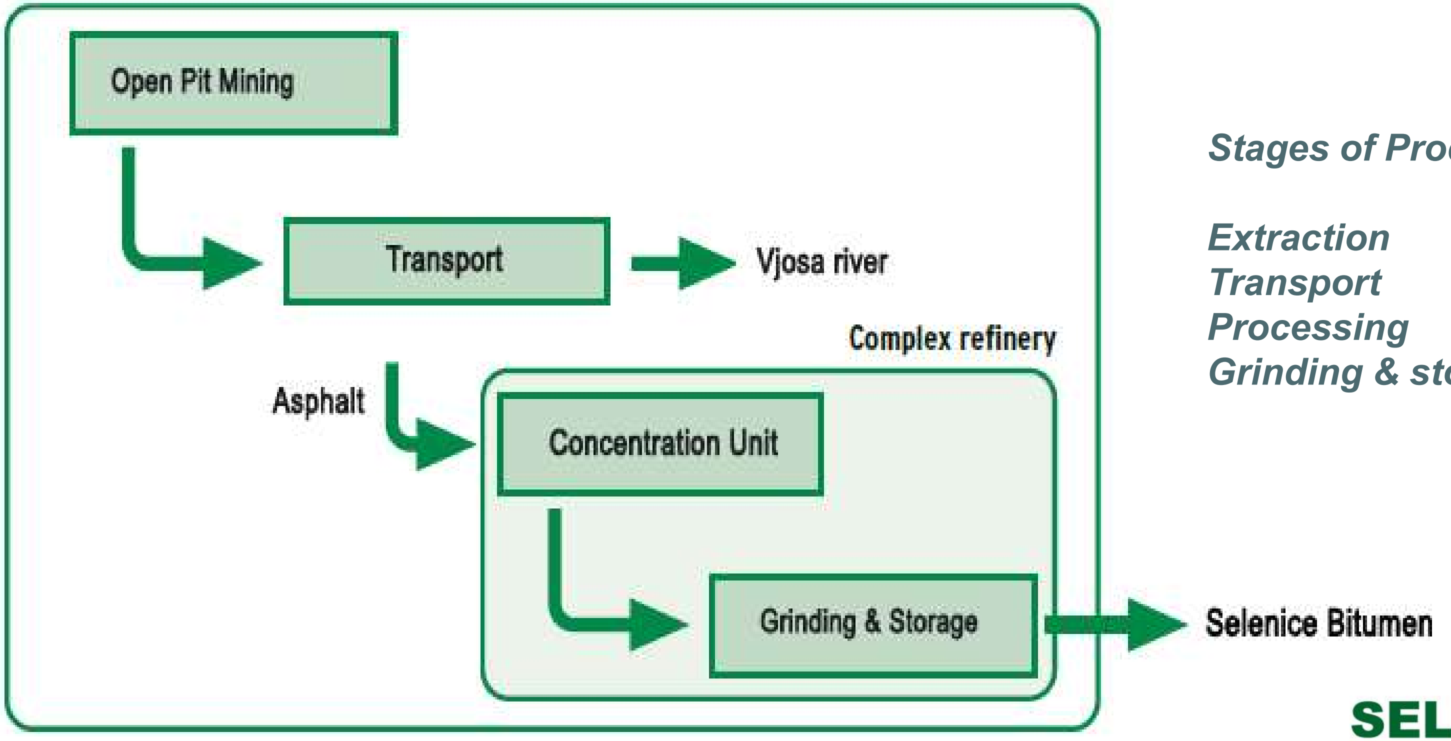
LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

The production chain** of natural bitumen **Selenizza

*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

SELENIZZA® NATURAL BITUMEN

LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

- 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

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NATURAL BITUMEN

LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

Consommation d'énergie et emisssion CO_2 pour l'asphalte naturel Selenizza

Production 1 tonne bitume (processus avec infrastructure)	unité	Extraction asphalte brut	Transport	Unité de Traitement	Stockage	Total
Matière première						
Asphalte brut	kg	1000				1000
Consommation de ressources énergétiques						
Essence	MJ/t	1,007				1,007
Diesel	MJ/t		0,066		0,001	0,067
Charbon bitumineux	MJ/t			0,339		0,339
Electricité	MJ/t					0,963
Total	MJ/t					**2,376**
Emissions dans l'air						
CO_2	g	59300	4500	59145		**127298**

LIFE CYCLE ASSESSMENT
SELENIZZA compared to petroleum bitumen

Comparing the results

Bitumes routiers de distillation

Total Consommation d'énergie	MJ/t					**4,71**
CO_2 Emissions dans l'air	g	144563	37422	7831		**226167**

L'asphalte naturel Selenizza

Total Consommation d'énergie	MJ/t					**2,376**
CO_2 Emissions dans l'air	g	59300	4500	59145		**127298**

- **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

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Conclusions |5

Conclusions

- **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**

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Thank you for your attention!

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