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MACEDONIAN ASSOCIATION OF ROAD ENGINEERS VIA VITA

NATURAL BITUMEN SELENIZZA APPROPRIATE CHOICE FOR HIGH PERFORMING ASPHALT MIXES

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Introduction

The mine of **Selenice** is located in southeast **Albania.**

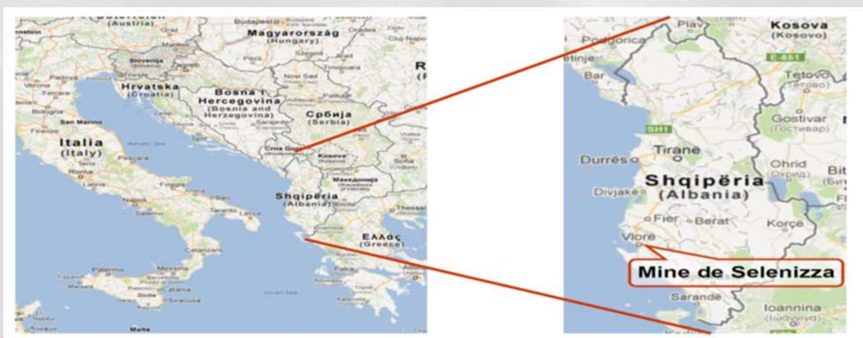
It has been mentioned since ancient times **by Aristotle &** actively exploited by **the Romans**.

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**



Natural Asphalts : modifiers of road bitumen

- **Thermo-rheological characterization**

Study was carried out by the University of Rome ***''LA SAPIENZA''***

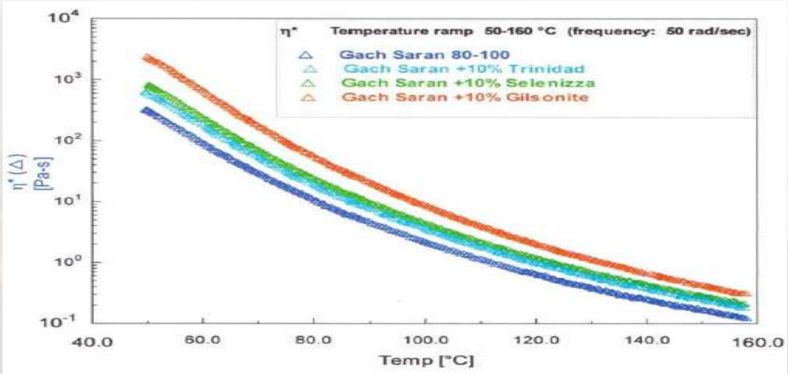
Three natural asphalts :

Straight Run bitumen, penetration grade **80/100 + 10 % natural asphalt**

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

Dynamic rheological analysis

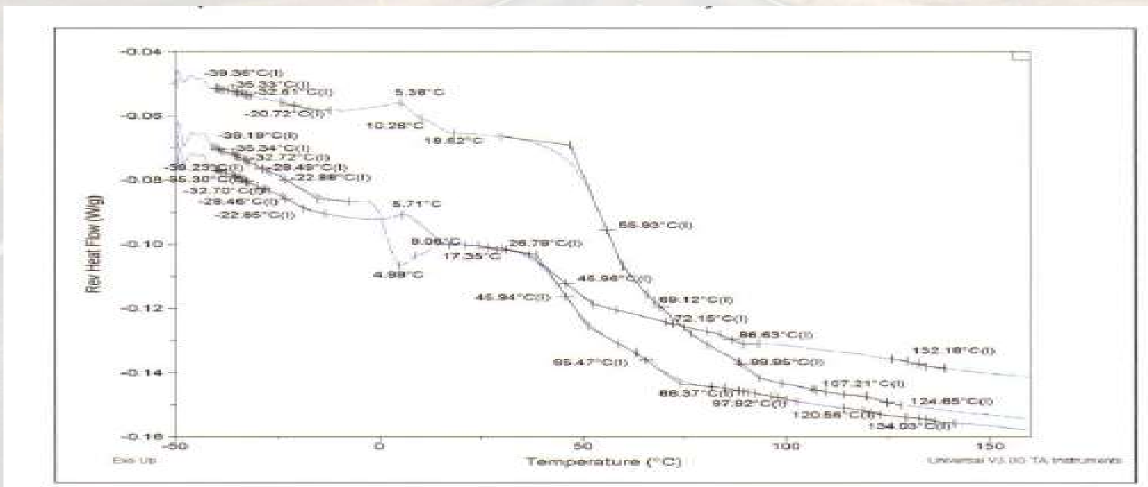
- Medium and high temperatures (**50 – 160°C**), depends exclusively on the asphaltenes content



- **Viscosity values increase,** the viscosity curves **shift upwards**
- **Modifiers don’t affect the** internal **interactions** between the **asphaltene components**
- **Compatible additives**

Modulated Differential Scanning calorimetry MDSC:

- **Reversing curve** is **more indicative** for **vitreous transitions**
- **Trinidad & Selenizza** : affect the **lower limit** of the softening range of the straight run bitumen (+55,8 °C ➔ 45,9°C), hence **dilution effect**
- **Gilsonite, only expands the softening** range to **higher temperatures**
- **Increase of consistency**, **viscosity** and **stability** of base bitumen



Characteristics of natural bitumen Selenizza

- ***Physic-chemical properties***
  - organic phase **similar** to petroleum bitumen, **higher content** of polar fractions
  - **vitreous transition** at **higher temperatures, colloidal instability sol** or **sol-gel**
  - addition of natural bitumen **does not affect the glass transition** of bitumen
  - 35/50 compared to modified alternative ➔ **T_g = - 23.1°C** versus **T_g = -19.3°C**
  - better resistance of natural bitumen to **brittle fracture**

IATROSCAN fractions

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

Evolution of Glass transition temperatures

	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% 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

Complex Modulus

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

Aging retarder

50/70 road bitumen + **5%, 10%** & **15 %** Selenizza

versus

equivalent bitumen **35/50, 20/30 & 10/20**

RTFOT tests (manufacturing) & **PAV** (in-service aging)

Aging effect was **quantified** using mathematical expression:

$$EVx = \frac{|x^{RTFOT+PAV} - x^{New}|}{x^{New}} * 100$$

EV_x: the evolution of mechanical property X

1. Changes of modified specimen, **lower** than those of **50/70**.

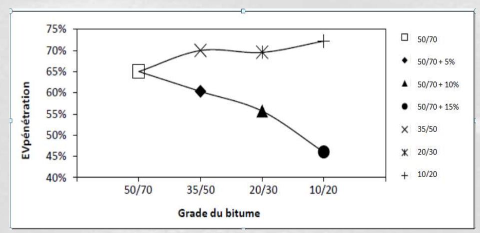
2. Changes are **attenuated** with the **increase** of the **%** SLN

3. Modified bitumen vs equivalent road bitumen are characterized by **minor changes**

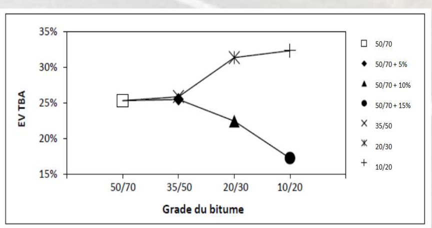
G*and **phase angles** show same trend in changes.

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

Evolution of penetration



Evolution of R&B



Highway implementation examples

HMA in Switzerland

*High-level of **traffic constraints &** Very **harsh climatic conditions (**-20°C to + 40 °C **)***
***➔ incorporated** in **national standard** the **HMA** concept*

- HMA **class 1** for improving rutting resistance
- HMA **class 2** for improving rutting & fatigue resistance

2 alternatives of mix design was tested:

3.9% Shell Cariphalte 25 RC**+ 1.4% SLN = 5.3%** (Selenizza **26%** of the total binder)

3.9% Shell Cariphalte 25 RC**+ 1.6% SLN = 5.5%** (Selenizza **29%** of the total binder)

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Modulus and Fatigue tests results **clearly exceed** the Swiss HMA **specifications** (14 000 MPa and 135 µdef).

To prevent the **cracking risk** at low temp., **final job** mix formula: **4.7%** Shell PmB **+ 1.4% SLN = 6.1%**

Modified binder ➔ **10/20** paving grade bitumen: **penetration** = **13 [0.1 mm]** and **TR&B = 86,7 [°C]**

Bonder composition	Unity	Mix design 1	Mix design 2
Shell Cariphalte 25 RC	%	3,9	3,9
Selenizza SLN	%	1,4	1,6
Theoretical binder content (¨% by mix mass)	%	5,3	5,5
Complex modulus at 15°C/10Hz (EN 12697-26)	MPa	19 441	18 336
Fatigue resistance at 10°C/25Hz (EN 12697-24)	µdef	139	145

ε_6 (extrapolated) ≈ **150 µdef**

Modulus (15°C/10 Hz) **= 15 100 MPa**

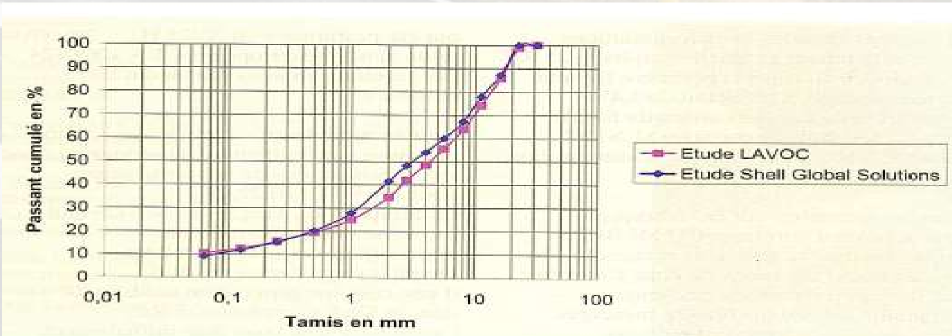


Figure 1
Courbes granulométriques des enrobés AC EME 22 testés


E35 E43 2 13
San Gottardo
San Bernardino
Lugano Nord
1000 m
49

Highway A8 “Olimpia Odos” (Greece)

375 km highway network designed according to **French Standards** applied to **Greek reality and experience**

Road structure ➔ **DBM** (Dense Bitumen Macadam) **base course**

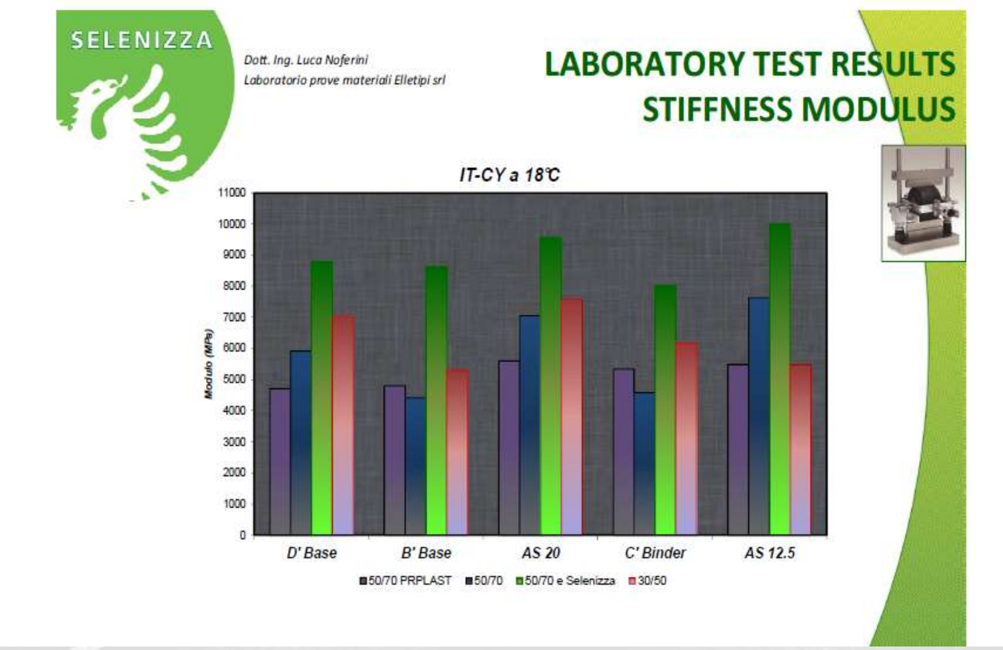
Anti-rutting **binder course AC (5 cm)**

Anti-skid **TAC** (thin asphalt concrete) **wearing course (2.5 cm).**

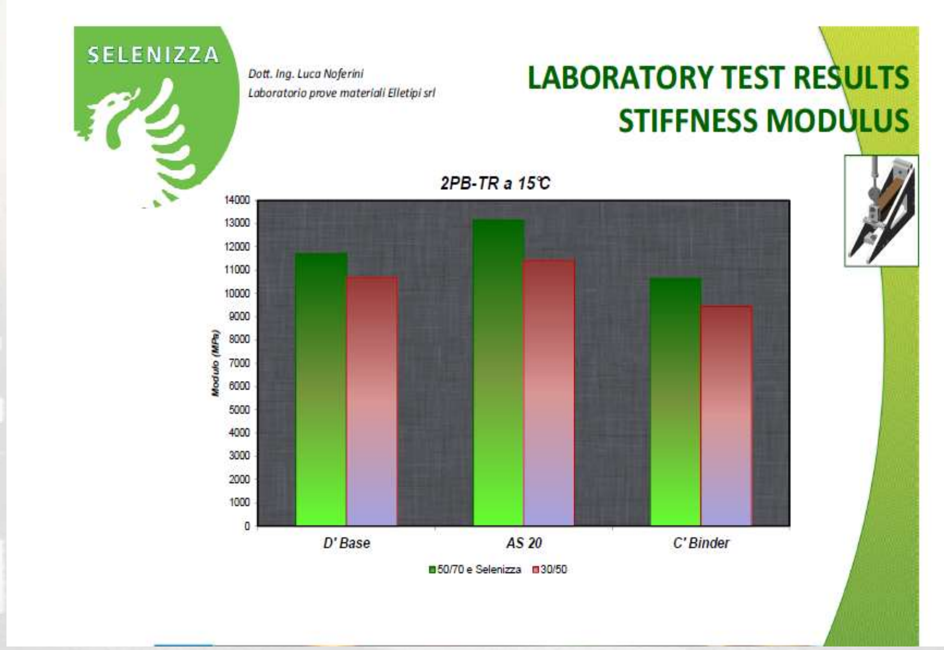
Base & Binder Courses ➔ tested different kind of binders:

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

STIFFNESS MODULUS (Indirect Tensile Test)



STIFFNESS MODULUS (Two Point Bending Test)

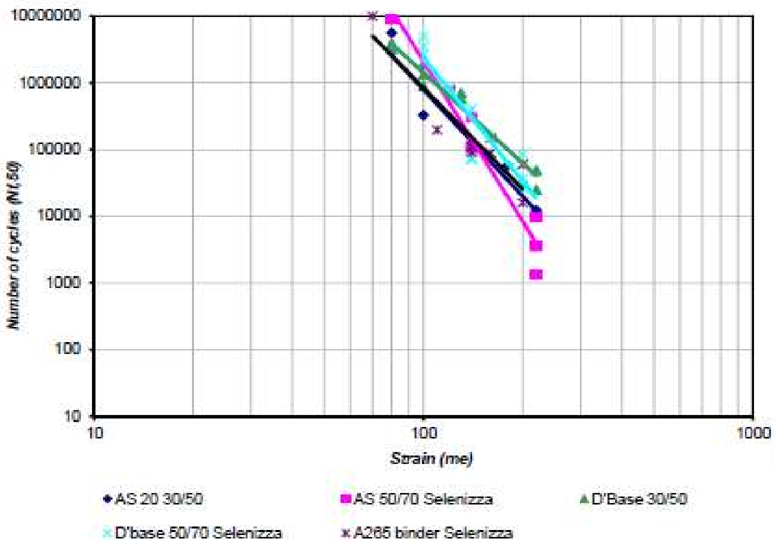


SELENIZZA

Dott. Ing. Luca Noferini
Laboratorio prove materiali Elletipi srl

LABORATORY TEST RESULST FATIGUE RESISTANCE 2PB-TR

SUMMARY OF FATIGUE TESTS 2PB-TR, 10°C, 25 Hz



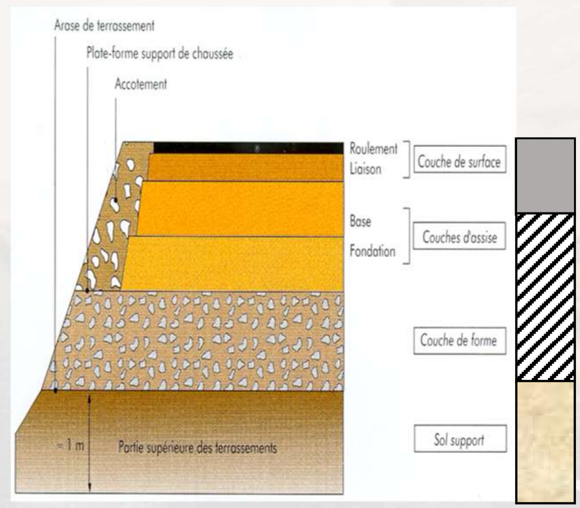
Material	*Bituminous binder*	*Fatigue ε6 10 °C, 25 Hz*	*Class asphalt mix*
STS A265 B' binder course	50/70 + 8% Selenice Pen = 39	*101.6*	DBM4
STS A 260 D' base course	30/50 Pene = 45	*108*	DBM3
STS A 260 D' base course	50/70 + 8% Selenizza Pen=39	*112*	DBM4
AS 20 base course	50/70 + 8% Selenizza Pen = 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
ν	0,35	0,35	0,35	0,35	0,35	0,35
Kc	-	-	1,3	1,3	1,3	1

Binder **50/70 + 8% Selenizza** higher **Stiffness and Fatigue performance ➔ Asphalt Mix** belongs to **higher project category DBM 4**, making **possible to reduce** the road package **thickness** by at least **4 cm.**


Thessaloniki
Exit

Highway A 150 (FRANCE)



PROJECT DESCRIPTION

17,5 km new roadway in A **150 Highway** technical specifications according to the CE standard NF EN 13108-1, was implemented base course **EB 14 ASSISE 20/30**

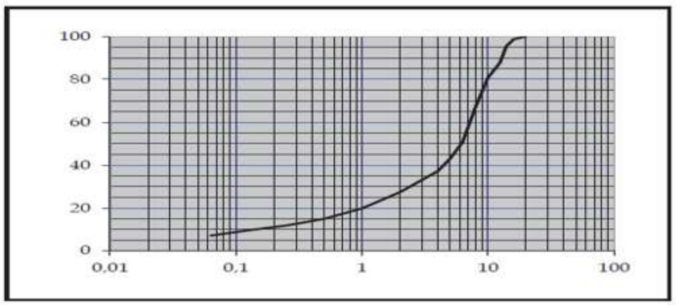
Two types of binders were analyzed:

- *The basic HMA mix design*: **30% RAP**+ **20/30** penetration grade bitumen
- *Alternative studied*: **30% RAP** + **50/70** grade bitumen **+ 1,5 %** Selenizza SLN

HMA 0/14 ➔ **20/30** + 30% **RAP**

FORMULE

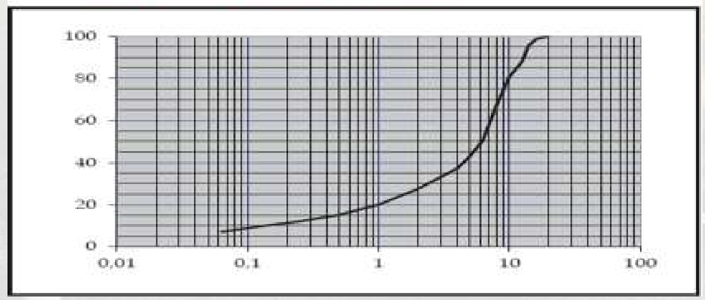
19,5%	0/5	STEMA		
21,8%	5/8	STEMA		
12,3%	8/11	STEMA		
11,4%	11/16	STEMA		
1,4%	FILLER	CONS		
29,9%	AE			
	apport liant AE		*avec*	5,0 %TL
3,7%		20/30		
5,2%		BITUME TOTAL		



HMA 0/14 ➔ **50/70** + **30% RAP** + **Selenizza**

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		



Same composition of materials, **grading curve** and **% of binder**

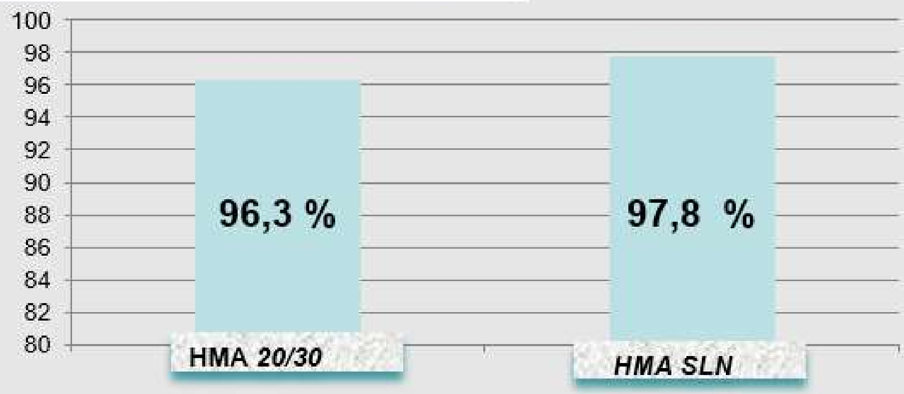
Water sensitivity

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/m^3	2,767	C_W à 18° kPa	17250
MVR t/m^3 *	2,545	*i*/C (%)	**96,3**
MVA t/m^3	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/m^3	2,766	C_W à 18° kPa	20178
MVR t/m^3 *	2,544	*i*/C (%)	**97,8**
MVA t/m^3	2,418	K	3,46

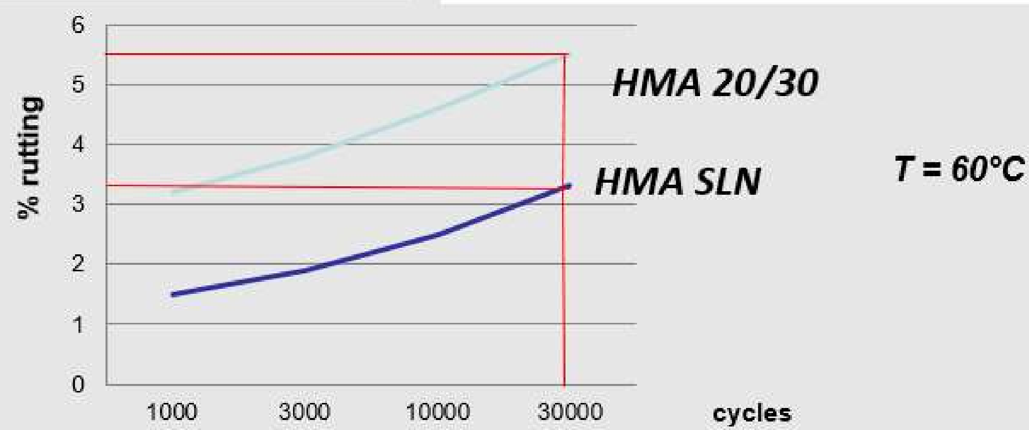


The 2 specimen were compacted at the same void percentage 5%

Resistance to rutting

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%*

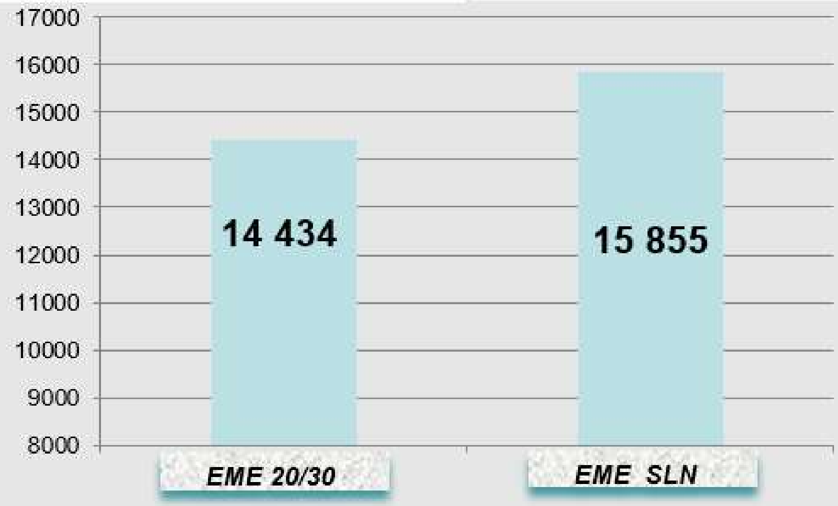
ESSAI D'ORNIERAGE *EN 12697-22*		
% de vides des éprouvettes 4,7 %		
N Cycles	% ornière moyen	Specific.
1 000	1,5%	
3 000	1,9%	
10 000	2,5%	
30 000	3,3%	*< 7,5%*



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

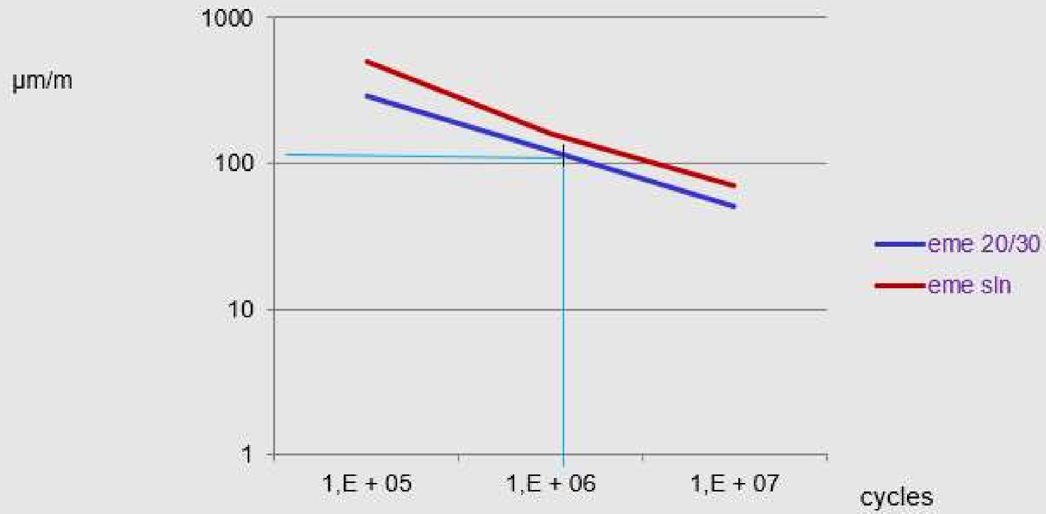
Fatigue

HMA 20/30

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

HMA SLN

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



T = 10 °C
f = 25 Hz

The study results **validated the** approach which consists in manufacturing the recycled HMA using a straight run bitumen **50/70 + 1,5 %** *Selenizza.*

LIFE CYCLE ASSESSMENT

SELENIZZA** vs **petroleum bitumen

Need for **bituminous binders** that meet **Life Cycle Assessment constraints, quantifying** the **environmental impact** of construction materials and comparing **potential solutions** based on **scientific data**

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

University of Rome in cooperation with the company **Selenice Bitumi,** carried out e **research project,** 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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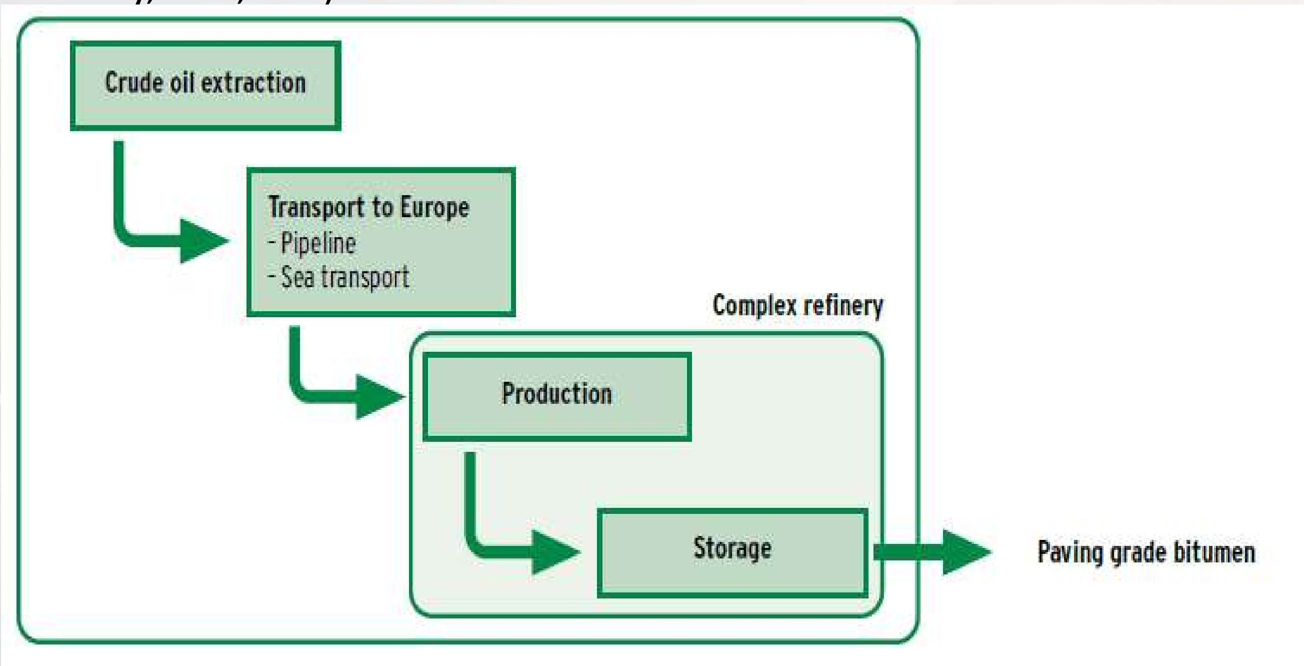
Petroleum bitumen production chain (cradle to grave approach)

Guidelines of **EU regulations** (ISO 1440 and 14044) for **environmental assessment, LCA** and **LCI.**

Data made available from **relevant bodies** and specialized **agencies** such as **Eurobitume** & **EAPA**

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

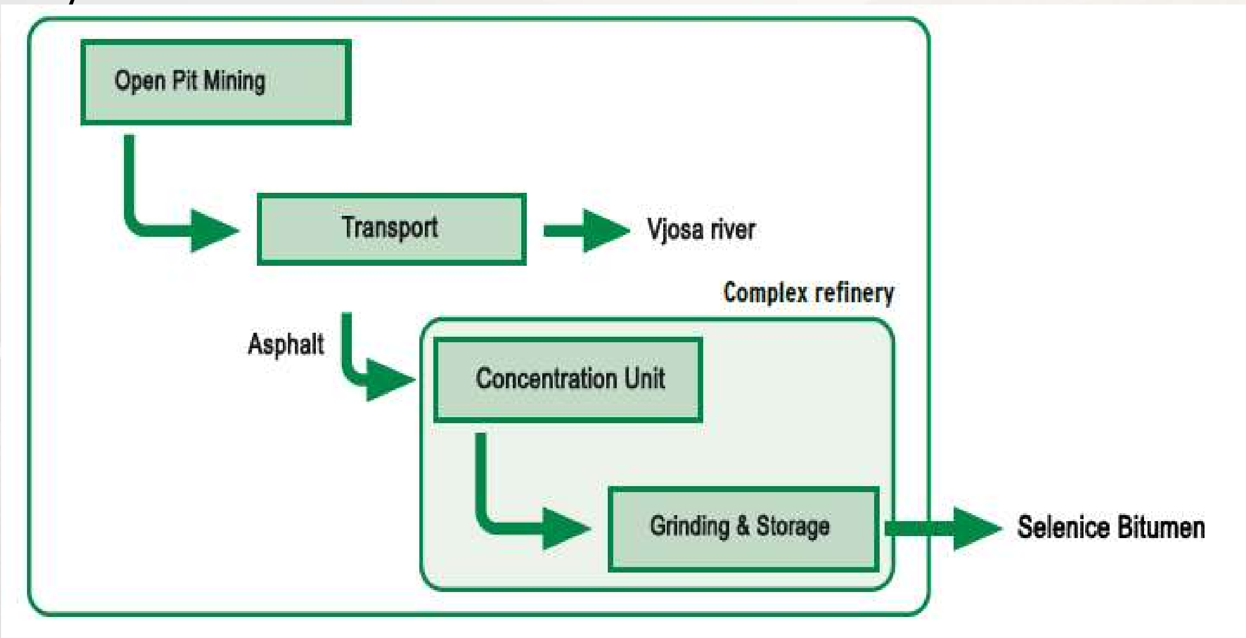


Deposit of natural bitumen Selenizza

The production chain** of natural bitumen **Selenizza

*The production process is **far simpler** 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***

Selenice manufactures on site: 1. **Raw ore** (natural bitumen) 2. **The fuel** (bituminous coal) used for refining ore in furnaces 3. **The residual inorganic materials,** transported and **deposited** close to a **river in** the vicinity



Comparison of 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

CONLUSIONS

- **100% compatible** with petroleum bitumen & PmB
- **High Permanent Deformation Performance HMA**
- Improved **adhesion** of **bitumen on the aggregates**
- Reduction in Pavement **thickness**
- Better **workability of asphalt**
- **Aging retarder & long-life** flexible pavements for heavy traffic
- **Environmentally friendly** bitumen

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Thank you for your attention