WARRIP

WESTERN AUSTRALIAN ROAD RESEARCH AND INNOVATION PROGRAM

High Modulus Asphalt (EME2)

2016-001

Dupuy Conceils Report

Dupuy Conseils

AN INITIATIVE BY:

THE GOVERNMENT OF WESTERN AUSTRALIA

mainroads WESTERN AUSTRALIA

arrb AUSTRALIAN ROAD RESEARCH BOARD

High Modulus Asphalt (EME2)
2016-001

Report 2 of 3

for Main Roads Western Australia

Reviewed	
Project Leader	Willie Valenzuela
Quality Manager	Dr Elsabe van Aswegen

PRP-16-8
August 2018

ABN 68 004 620 651

Victoria
500 Burwood Highway
Vermont South VIC 3133
Australia
P: +61 3 9881 1555
F: +61 3 9887 8104
info@arrb.com.au

Western Australia
191 Carr Place
Leederville WA 6007
Australia
P: +61 8 9227 3000
F: +61 8 9227 3030
arrb.wa@arrb.com.au

New South Wales
2-14 Mountain St
Ultimo NSW 2007
Australia
P: +61 2 9282 4444
F: +61 2 9280 4430
arrb.nsw@arrb.com.au

Queensland
123 Sandgate Road
Albion QLD 4010
Australia
P: +61 7 3260 3500
F: +61 7 3862 4699
arrb.qld@arrb.com.au

South Australia
Level 11,
101 Grenfell Street
Adelaide SA 5000
Australia
P: +61 8 7200 2659
F: +61 8 8223 7406
arrb.sa@arrb.com.au

International office
770 Pennsylvania Drive
Suite 112
Exton, PA 19341
USA
Tel: 610-321-8302
Fax: 610-458-2467

DUPUY Conseils
Rés La Grand Voile Appt F3
9 impasse des Chagos
97419 LA POSSESSION
FRANCE

ARRB

191 carr Place

Leederville

WA 6007 - AUSTRALIA

Le Port 29/04/2017

Number of sheets: 44

Tonkin Highway Intersection Improvments–
Trial Enrobés à Module Elevé 0/14 classe 2 (EME 2)

Subject:

- Technical report

Dear client,

On the behalf of DUPUY Conseils please find a technical report edited after a campaign on field between 25th et 28th of april 2017.

Yours faithfully

Pierrick DUPUY

Special thanks:

On regard to the quality of the shares and the professionalism of the actors a particular thank is compulsory toward the application team and the staff but specially to Les MARCHANT, Steve HALLIGAN and Willie VALENZUELA.

Tonkin Highway Intersection Improvements

Trial EME 2

TECHNICAL REPORT

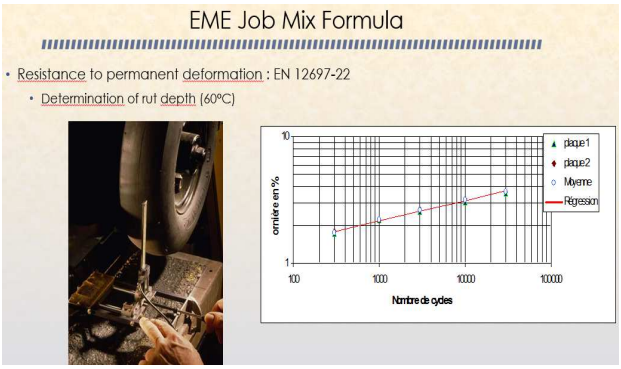
1 7 0 4 2 8	A R R B	P D U	C R T	0 2	0 1
Date (AAMMJJ)	*Marché* (NRL ou MTx)	*Aut.* (ex : LDe)	*Type* (PVE, NTE, CRV, CRR…)	*Aff.* (cf. liste)	*Inter.* (cf. liste)

SUMMARY

A Technical assistance mission has been asked to Pierrick DUPUY on regard to the application of an High Modulus Asphalt (= EME2) on a trial located on Tonkin Highway (Perth – WA). The report presents two parts of the mission executed between 25th and 28th april 2017.

On the one hand the details of the operations on site added with advice and improvement axis.

On the other hand, a complete presentation about EME2 (and commented on the 28th april within Main Road office) is presented. It deals with the fields of pavement structure design then formulation approach and depicts specifications about production to end with application and controls on field.



INDEX

1 INTRODUCTION

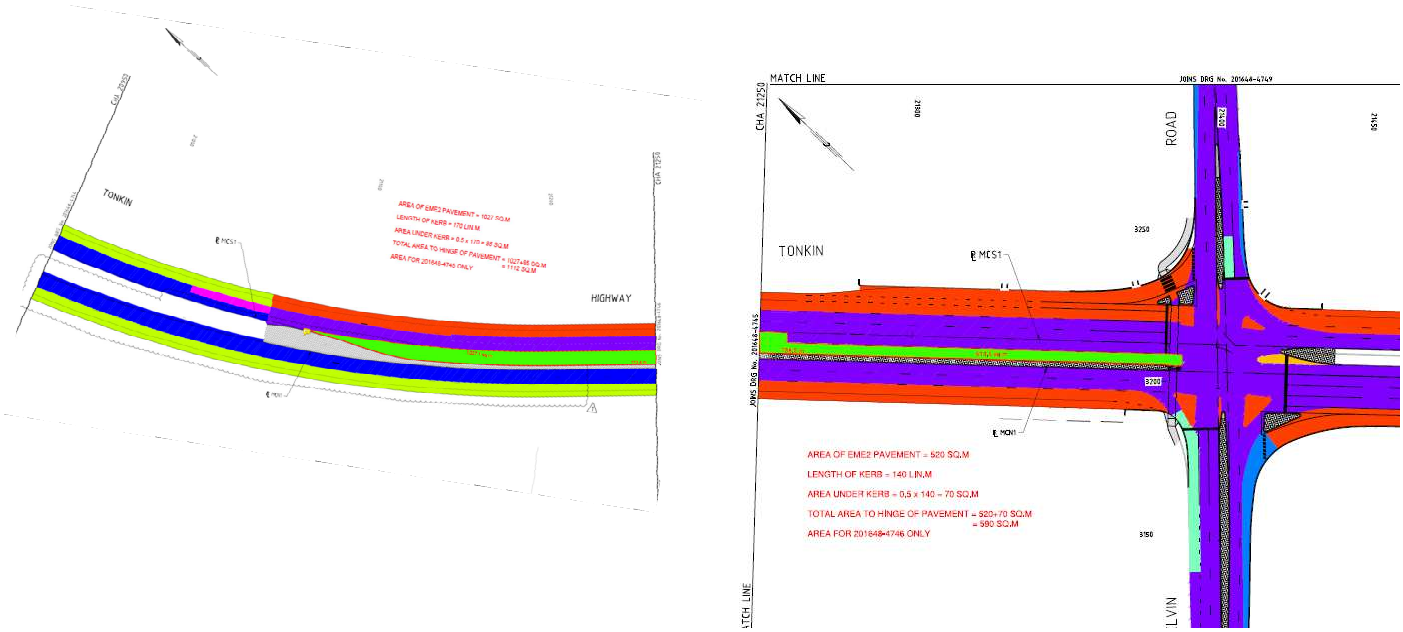
On the demand of the contractor ARWB, its technical support ARRB has been designated to lead an operation of technical assistance thanks to the support of a qualified expert in the field of road construction and specifically in EME 2 for High Modulus Asphalt class 2.

The mission of Pierrick DUPUY is based on the participation to a trial in the surroundings of PERTH (Western Australia Province) at the intersection of Kelvin Road and Tonkin Highway and ends with a presentation wich deals with all the aspects of the use of EME2.

2 TRIAL ON TONKIN HIGHWAY – OBSERVATIONS AND IMPROVEMENT AXIS

2.1 Context

On the 26th of April the purpose is the application of 2 layers of 105 mm of EME as indicated on the plan below:



EME Trial area (ligh green) (Surf approx. . 1500 m²)

The presence on field is dedicated to a technical support and a material inspection.

2.2 Quality of the support

The support is characteristic of a compacted limestone with a general homogeneity in terms of gradation. Visually the product has been correctly compacted and present a moisture close to the Optimum Proctor Point (= maximum density) without visible lack of density.

The general geometry of the site with an elevation of 25 m added to the absence of table water and a roof top profile reduces the risks of bearing capacity decrease.

Improvement Axis: The use of a prime coat might be seen as an additional security in regard to the structure and the longevity of the pavement. As a fact the emulsion permeability is a property useful for the integrity of the lower part of the EME2 and reduces at long term the risk of bitumen degradation within a section solicited in traction. Even if the geometry of the trial prevents from this issue it might be a disposition to take on other situation.

Eventually the modelization approach takes in account a full bonding between limestone and EME2 and a lack of it can increase the strains at the interface and decrease service life of the pavement.

2.3 Material inspection

The material on site is adapted to the need and even more to face breakage issue thanks to extra compaction machines at disposal.

Nature	Paver	Cylinder 1	Multi	Cylinder 2	*Cylinder 3*
Brand – Model	/	HAM HD 070 V-ASC	HAM GRW 280	HAMM HD 90 VOS	*BOMAG BW 100*
Caracteristics	Wheels	Vibration		Oscillation	*(Not used)*
Classification *	Wheels	Vt2	P1	Vt2	*Vt2*
Width	Wheels	1.7 m	2.1 m	1.7 m	*1.0 m*
Visual maintenance	Good	Good	Good	Good	Good

- French standards (depends on weight, width, amplitude and frequency)

The compaction train is heavily constituted and is not in this case the limiting factor of the operation. As a matter of fact, the asphalt plant will be the unity on which the duration of the operation will depends.

The plant visited is a continuous mix plant and not brand new but characterized by a high level of maintenance. The stock piles are clearly separated and aggregates present an excellent cleanliness and a good angularity especially for the sand.

As it will be confirmed,despite the low rate of production around 100 tons per hour the accuracy of grading curve and binder content will be one of the most positive aspect of the trial.

2.4 Application

The application beagn at 11:30 am and EME2 temperature is measured behind the paver at 165°C .

Improvement Axis: A large technical staff is at disposal for asphalt control and temperature control. Even if thermic cameras could identify heterogeneity behind the paver and Infrared thermometer are also useful they do not indicate the internal temperature which is the most important to compare with specifications (min 145°C) and to guaranty the workability.

So in that case the use of abrasion resistant thermocouple is recommended.

The geometrical aspect of the trial is frequently encountered on road asphalt application. On the contrary to new roads projects, the current operation suffers from width variation and punctual thickness evolution. In that case, the rolling pattern has to be seen as a guideline with permanent adaptation thanks to the visual aspect and the physical feelings on board of compactors.

On the top of that, the rolling pattern can be adapted constantly thanks to the pave tracker and the nuclear gauge at disposal.

Nature	Type	Number	Effect
Static cylinder	HAM HD 070 V-ASC	2 passes	Avoiding high deformations on “open” surface asphalt
Vibrating cylinder	HAM HD 070 V-ASC	4 passes	Increasing general density
Static multi	HAM GRW 280	6-8 passes	Increasing bottom density
Oscillating* cylinder	HAMM HD 90 VOS	0-2 passes	Reaching the optimal density
Static cylinder	HAMM HD 90 VOS	2-4 passes	Erasing marks and give smooth aspect

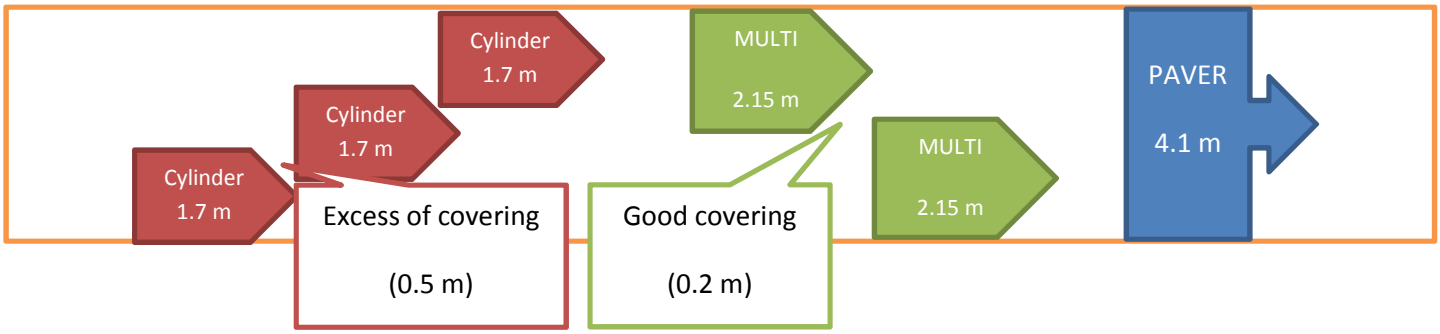
*Not compulsory for this application but of the utmost importance on bridges and concrete.

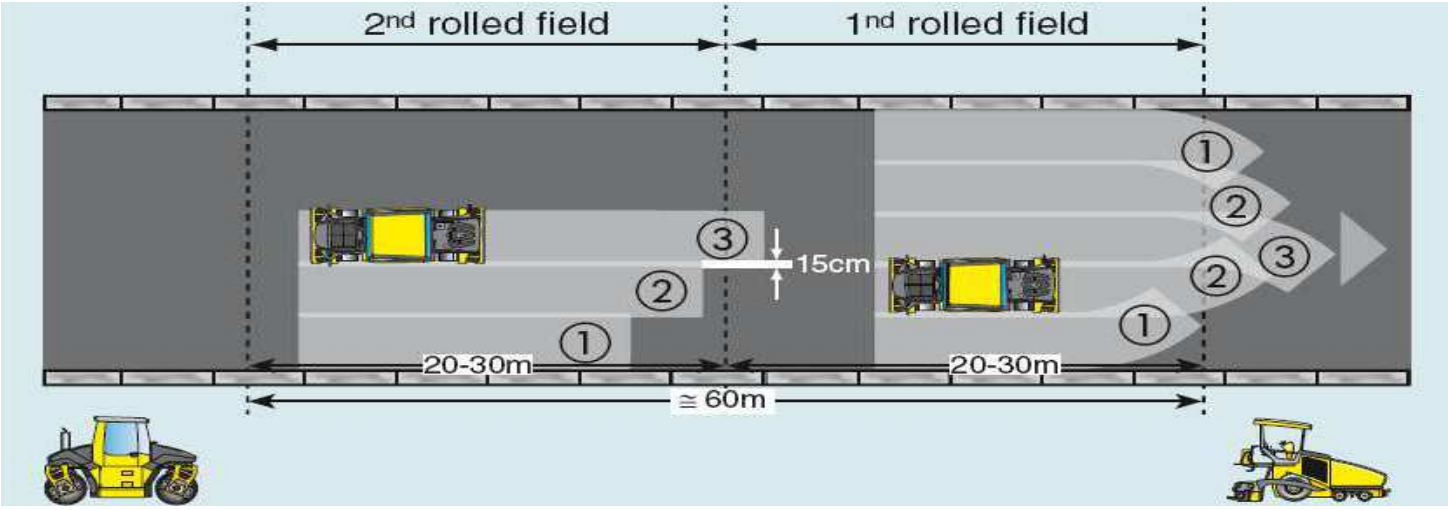
As a demonstration of application team efficiency, internal controls are frequent (thickness, temperature, density) and communication is permanent. If we get a closer look on the compaction train, each driver takes care of his compaction area and avoid the introduction of his compactor on new section without a visual approbation.

So as a result the general aspect is definitely homogenous but for rare and explicable situations.

Improvement Axis: The wandering pattern and the paver itinerary may be a bigger part of the preparation task. The study of width modification and specific tasks could have an impact on the density variation. As an illustration of it, the covering of bands reachs sometimes a high level (> 30 cm) so the mix of compactor type in terms of width could be useful.

Situation on field:





As it is said before, the low rate of production and the deliveries for other customers forces the paver to stop for long time (> 20 min.). This situation has many effects on the EME2 overall quality.

On the one hand the paver's table punches the EME2 particularly rich and leads to "geometrical short wave longitudinal" issues.

On the other hand, the compaction train adapts its behavior in two inappropriate manners:

- The first one leads to an excess of compaction due to the excess of passes and sometimes a "fear" from drivers for stopping the compactors.
- The second one in case of stop is to not reach the paver and let a long distance with an high rate of voids level more difficult to reduce after the paver restart.

Improvement Axis: To guaranty the regularity of voids results on the longitudinal profile it is highly recommended to reduce the speed of the paver instead of stopping it. In that case and after more than 20 minutes of inactivity the table lifting is to be done and the compaction is to be finished. After that compactors must be parked far away from hot or warm asphalt to avoid massive punching (see below).

Application of a tack coat is done between the two EME2 layers. This operation is not as much supervised as the EME2 application despite the fact that the bond properties impact a lot the admissible properties during the modelisation process

So even if the surface is covered, some areas are exposed twice and other present a visual thin coat without forgetting punctual stripping situation.

Improvement Axis: In case of emulsion application few guidelines can be given depending on nature of asphalt

Product/Interface	Tap coat	Bitumen rate**	Emulsion
EME/EME*	Emulsion 60% of 20/30 bitumen	**250 gr/m²**	**420 gr/m²**
EME/EME*	Emulsion 65% of 35/50 bitumen	**250 gr/m²**	**380 gr/m²**

**other layers like surface layers with modified binder: ask precisions to bitumen supplier*

***NF P 98-150-1 (French application norm)*

Material used for this purpose deserves the same maintenance program than the others so annual calibration is highly recommended and daily verification of injectors is to be done to avoid stripping issues.

Eventually the longitudinal joint is a topic to be deal within this report even if it concerns not only EME but all asphalt products and surface layers in particular.

The execution program expose the squad to the treatment of a “warm” joint (> 50°C). In that case, a side roll is used to put apart 8 to 15 cm of EME from the edge.

Then the new band is executed with a covering of 3 to 4 cm before the beginning of compaction from the hot mix toward the warm mix by a diagonal approach. As a result, voids rates on field material is punctually over the limit of 6 % and a light and punctual lack of asphalt can be seen.

Improvement Axis: Unless it’s done by two pavers separated of less than 50 meters, the longitudinal joint is always a “weakness point”. In that case, it is recommended to respect a normal compaction pattern for the first band and overtake the asphalt of approximatively 10 cm over the edge.

Then, when the paver execute the second strip, the covering stay useful on 3 to 4 cm and a reject with the rake of gravel behind the table can be a way to let a sandy asphalt to close the surface of the joint. The compaction starts on the warm band with 5 to 20 cm of overtake and then, the compactor goes back to its normal rolling pattern.

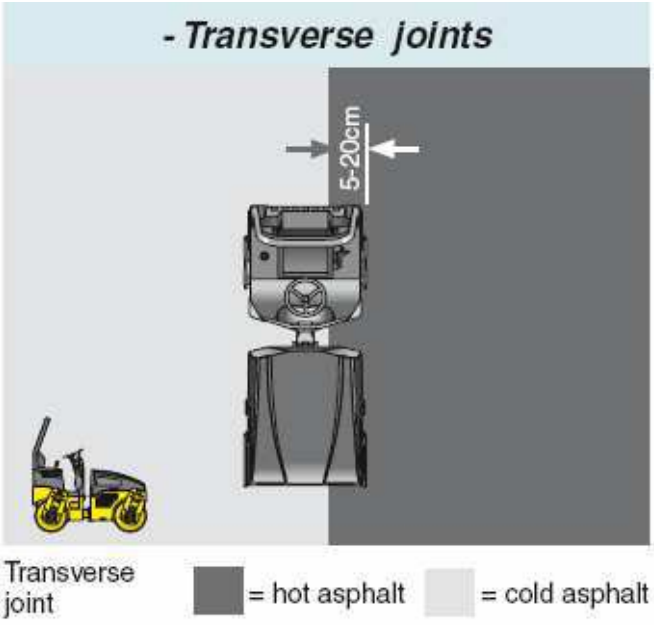


Fig. 67 Transverse joint without traffic

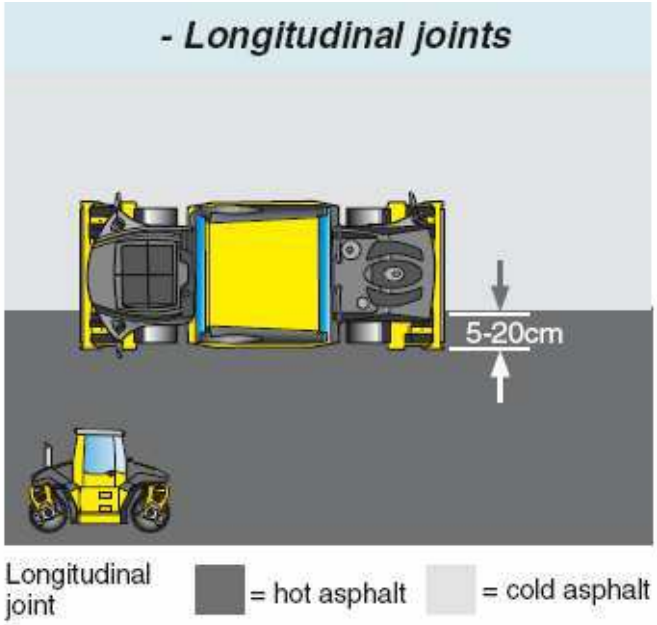


Fig. 68 Longitudinal joint without traffic

1 7 0 4 2 8	A R R B	P D U	C R T	0 2	0 1
Date (AAMMJJ)	*Marché* (NRL ou MTx)	*Aut.* (ex : LDe)	*Type* (PVE, NTE, CRV, CRR…)	*Aff.* (cf. liste)	*Inter.* (cf. liste)

3 MEETING AND PRESENTATION

The technical mission is concluded by a presentation which develops all the aspects of EME2 and so overtake the execution process to describe the structural approach and formulation aspects.

The entire presentation is attached to this report as an appendix.

4 APPENDIX

- WA Road Research and Innovation Program (WARRIP) “High Modulus Asphalt (EME2)” (33 pages)

Rédigé par
Pierrick DUPUY
Director

WA Road Research and Innovation Program (WARRIP)

High Modulus Asphalt (EME2)
Enrobé à Module Élevé

8:30am – 10:30am
Friday 28th April 2017
Main Roads Materials Engineering Branch,
5-9 Colin Jamieson Drive, Welshpool

Pierrick DUPUY

Technical manager – Road Construction and Civil Engineering

Nouvelle Route du Littoral – Reunion Island (France)

Quality control and Technical services



Nouvelle Route du Littoral
http://www.nouvelleroutedulittoral.re/
2014-....


Roland Garros Airport- Expansion of runways and taxiway
http://www.nouvelleroutedulittoral.re/
2013

Route des Tamarins
Viaducs de la Savane
2005-2006

Toulouse
EADS - Aéroconstellation

Route des Tamarins
Lot chaussées nord
2007-2009

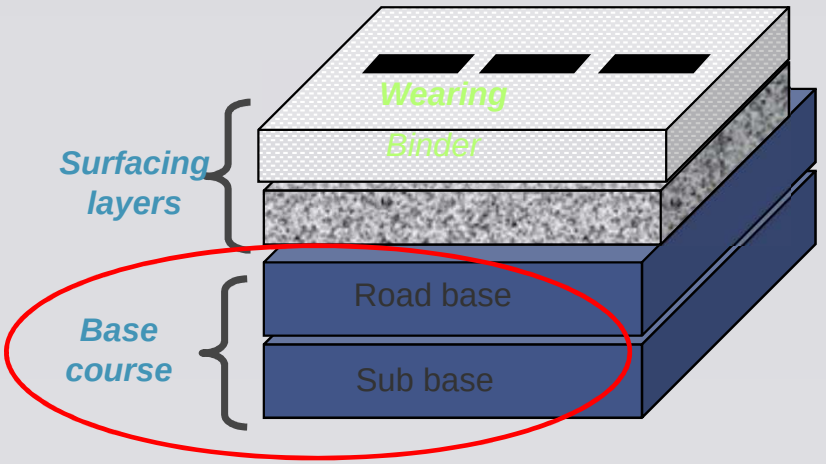
A89
Mussidan- Périgueux

Route des Tamarins
Viaduc de Saint Paul
2005-2009

RN141-Déviation de Jarnac
2002

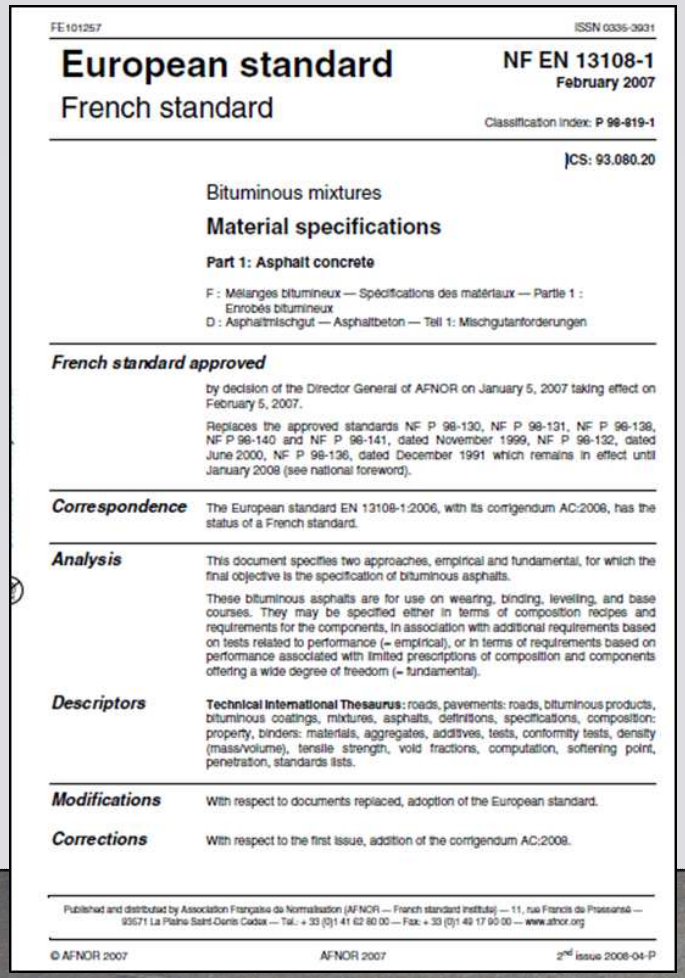
Origins of the High Modululs Asphalt - EME

- Improving characteristics of “Basic” Road Base Asphalt Concrete
- Optimizing thickness according to pavement design
- Saving cost and delay
- First introduction in France : mid 80’s
- Reinforcement, Construction works, Heavy Structures



Standardisation and comparative analyse

- European Standard EN 13108-1



FE101257 ISSN 0335-3931

European standard **NF EN 13108-1**
February 2007

French standard

Classification index: P 98-819-1

ICS: 93.080.20

Bituminous mixtures

Material specifications

Part 1: Asphalt concrete

F : Mélanges bitumineux — Spécifications des matériaux — Partie 1 : Enrobés bitumineux
D : Asphaltmischgut — Asphaltbeton — Teil 1: Mischgutanforderungen

French standard approved

by decision of the Director General of AFNOR on January 5, 2007 taking effect on February 5, 2007.

Replaces the approved standards NF P 98-130, NF P 98-131, NF P 98-138, NF P 98-140 and NF P 98-141, dated November 1999, NF P 98-132, dated June 2000, NF P 98-136, dated December 1991 which remains in effect until January 2008 (see national foreword).

Correspondence The European standard EN 13108-1:2006, with its corrigendum AC:2008, has the status of a French standard.

Analysis This document specifies two approaches, empirical and fundamental, for which the final objective is the specification of bituminous asphalts.

These bituminous asphalts are for use on wearing, binding, levelling, and base courses. They may be specified either in terms of composition recipes and requirements for the components, in association with additional requirements based on tests related to performance (= empirical), or in terms of requirements based on performance associated with limited prescriptions of composition and components offering a wide degree of freedom (= fundamental).

Descriptors **Technical International Thesaurus:** roads, pavements: roads, bituminous products, bituminous coatings, mixtures, asphalts, definitions, specifications, composition: property, binders: materials, aggregates, additives, tests, conformity tests, density (mass/volume), tensile strength, void fractions, computation, softening point, penetration, standards lists.

Modifications With respect to documents replaced, adoption of the European standard.

Corrections With respect to the first issue, addition of the corrigendum AC:2008.

Published and distributed by Association Française de Normalisation (AFNOR — French standard institute) — 11, rue Francis de Pressensé — 93571 La Plaine Saint-Denis Cedex — Tel.: + 33 (0)1 41 62 80 00 — Fax: + 33 (0)1 49 17 90 00 — www.afnor.org

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	GB class 2	GB class 3	EME class 1	**EME class 2**
Binder content	> 3.8%	> 4.2%	No minimum	**No minimum** (But TBA++ and %++)
Stiffness modulus E* (Mpa) 15°C – 10 Hz	> 9,000	> 9,000	> 14,000	**> 14,000**
Fatigue ε6 (µdef) 10°C – 25 Hz	> 80	> 90	> 100	**> 130**

Thickness	GB class 2	GB class 3	EME class 1	**EME class 2**
0/14 mm	**(8 to14 cm – 6 min)**		**(7 to13 cm – 6 min)**	
0/20 mm	(10 to16 cm – 8 min)		(9 to15 cm – 8 min)	

Road Pavement design

- 1994: The French Design Manual for Pavement Structures
- 1997: English version
- 2011: Update French Standard NF P 98 086

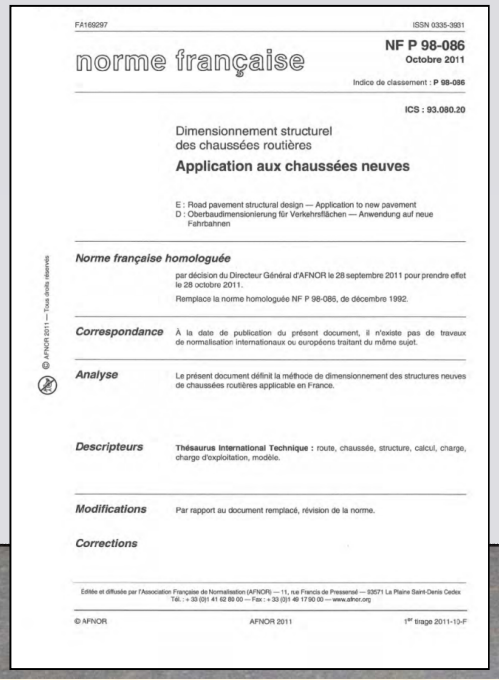
LOCAL APPLICATION

BUT BASED ON

COMMON MECHANICAL THEORIES

(Stiffness, fatigue,..)

LCPC Laboratoire Central des Ponts et Chaussées



FA169297 ISSN 0335-3931

norme française

NF P 98-086
Octobre 2011

Indice de classement : P 98-086

ICS : 93.080.20

Dimensionnement structurel
des chaussées routières
Application aux chaussées neuves

E : Road pavement structural design — Application to new pavement
D : Oberbaudimensionierung für Verkehrsflächen — Anwendung auf neue Fahrbahnen

Norme française homologuée

par décision du Directeur Général d'AFNOR le 28 septembre 2011 pour prendre effet le 28 octobre 2011.

Remplace la norme homologuée NF P 98-086, de décembre 1992.

Correspondance À la date de publication du présent document, il n'existe pas de travaux de normalisation internationaux ou européens traitant du même sujet.

Analyse Le présent document définit la méthode de dimensionnement des structures neuves de chaussées routières applicable en France.

Descripteurs **Thésaurus International Technique :** route, chaussée, structure, calcul, charge, charge d'exploitation, modèle.

Modifications Par rapport au document remplacé, révision de la norme.

Corrections

Éditée et diffusée par l'Association Française de Normalisation (AFNOR) — 11, rue Francis de Pressensé — 93571 La Plaine Saint-Denis Cedex
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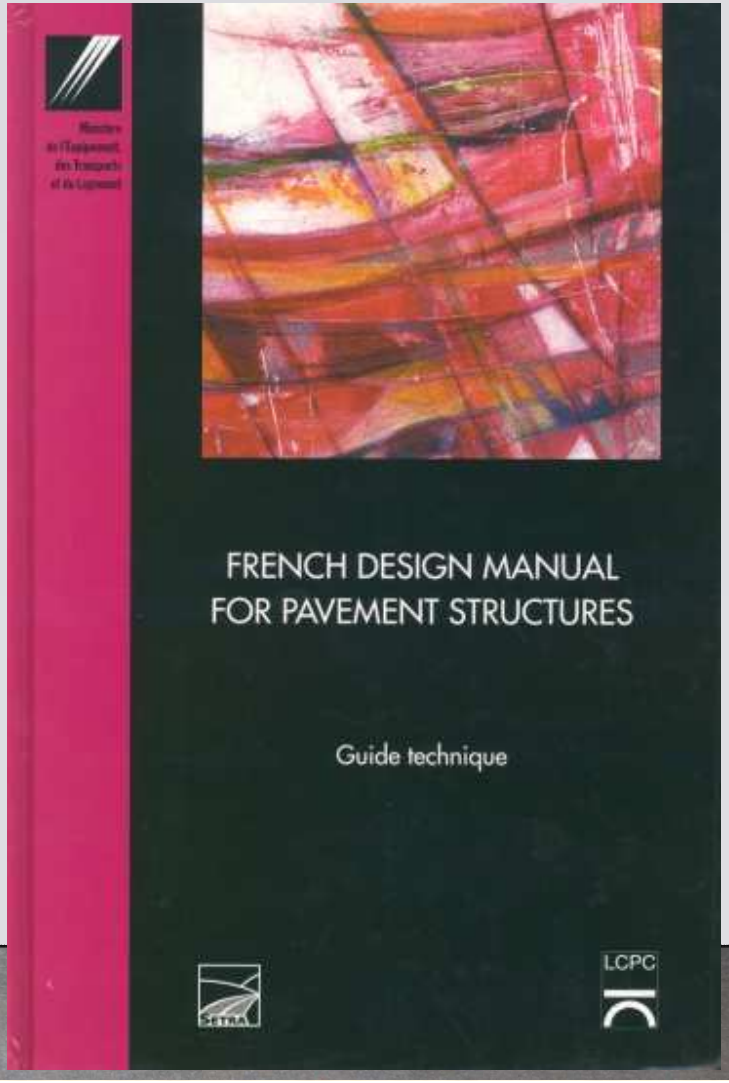


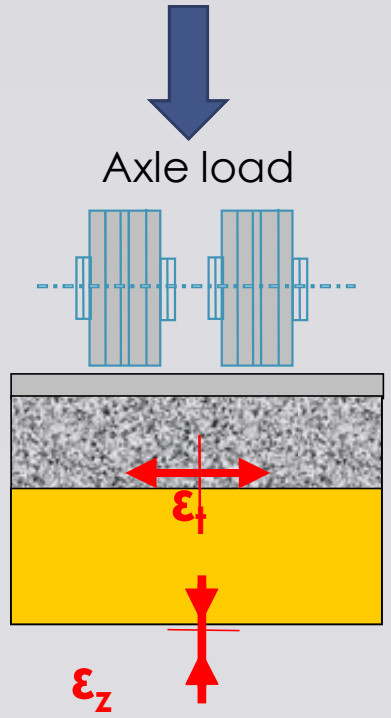
Road Pavement design

- How to make the best use of the characteristics measured in the laboratory taking into account the actual service conditions?

Structural modeling

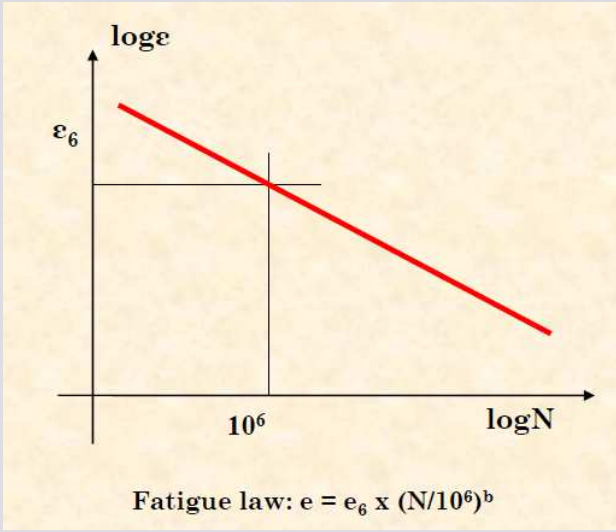
Alizé-Lcpc - Résultats (Structure : données écran, Charge de référence

épaiss. (m)	module (MPa)	coef. Poisson	Zcalcul (m)	EpsT (µdéf)	SigmaT (MPa)	EpsZ (µdéf)	SigmaZ (MPa)
0,050	5400,0	0,350	0,000	77,9	0,864	-76,0	0,657
			0,050	38,0	0,447	11,4	0,555
Tack coat	collé						
0,100	9300,0	0,350	0,050	38,0	0,763	-15,5	0,555
			0,150	-155,0	-1,967	143,2	0,077
Prime coat	collé						
infini	120,0	0,350	0,150	-155,0	0,015	535,8	0,077



Road Pavement design

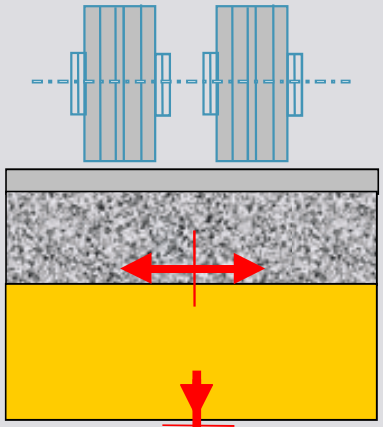
- How to make the best use of the characteristics measured in the laboratory taking into account the actual service conditions?



$$\varepsilon_{t,ad} = \varepsilon\,(NE, \theta_{eq}, f)\, k_r\, k_c\, k_s$$

Road Pavement design

Reference
Axle load



$\varepsilon_t < \varepsilon_{t,ad}$

$\varepsilon_z < \varepsilon_{z,ad}$

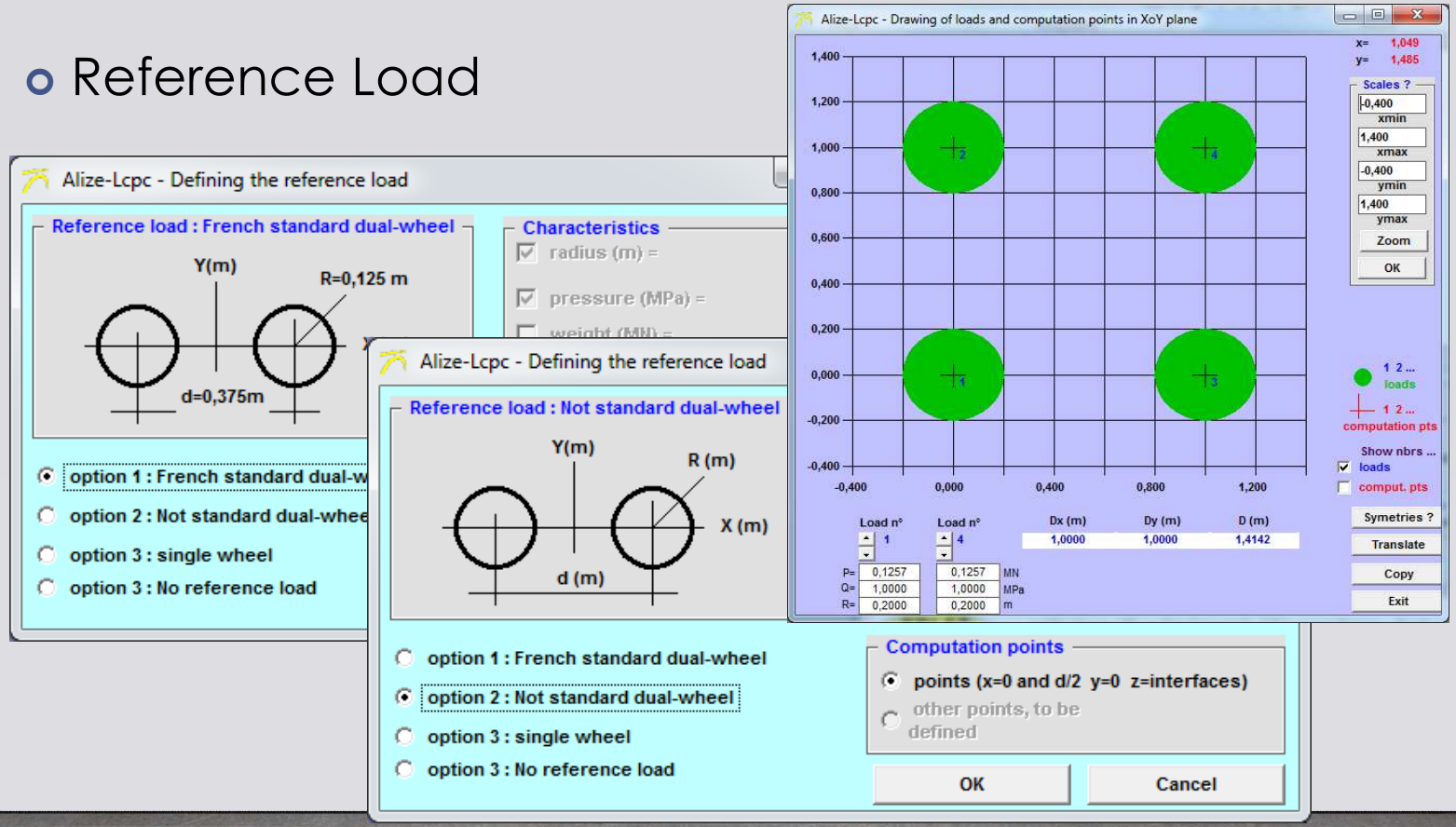
$$\varepsilon_{t,ad} = \varepsilon\,(NE, \theta_{eq}, f)\; k_r\, k_c\, k_s$$

Road Pavement design

- How to adapt French Road Pavement Design Method to other context :
  - Reference Load
    - Standard axle / country
    - Specific load
  - Modulus / Fatigue values
    - Temperature (climate)
    - Frequency (speed limit)

Road Pavement design

- Reference Load



Road Pavement design

- Equivalent Temperature

$$D_{eq} = \left[\frac{\varepsilon eq}{\varepsilon_6(\theta eq)}\right]^{1/b} \times 10^{-6} \sum_i n_i = \sum_i n_i \left[\frac{\varepsilon_t}{\varepsilon_6(\theta_i)}\right]^{1/b} \times 10^{-6}$$

	Teq
Paris	15°C
Sydney	18°C
Mauritius	25°C
Bangkok	30°C

COLAS

Direction Technique, Recherche et Développement — Centre d'Expertise et de Documentation

Confidentiel à usage interne

Magny les Hameaux, le 20/12/10

RAPPORT DE PRESTATION
n° 101075

Températures équivalentes Thaïlande et Australie

Demandeur : Etienne LE BOUTEILLER (DT DGI)
Réf demandeur :

Autres destinataires :
- P. RAFFIN (DTRD)
- J-L. SAUTIER (DT CED)

Résumé

L'objet de cette note est de définir une température équivalente de dimensionnement pour la Thaïlande et l'Australie, dans le but de formuler des EME et de tester leurs performances en s'adaptant aux conditions climatiques locales.

La charge considérée est l'essieu légal en Thaïlande de 8,6t.
Trafic : 600 PL/jour
Les structures considérées pour l'étude ainsi que les températures équivalentes sont :

Thaïlande	Australie
6 BBME	6 BBME
16 EME	18 EME
PF2	PF3
28,2 °C	17,75 °C

En première approche, cette étude montre que la température équivalence correspond quasi exactement à la température moyenne du pays.
Ces résultats sont valides dans le cadre strict des hypothèses détaillées dans le rapport ci-joint. Si de nouvelles hypothèses sont à prendre en compte, il convient alors de procéder à un nouveau dimensionnement.

La responsable de la prestation
Sandrine BUYTET

Vérifié le 15/12/2010 par Pierre CIXOUS

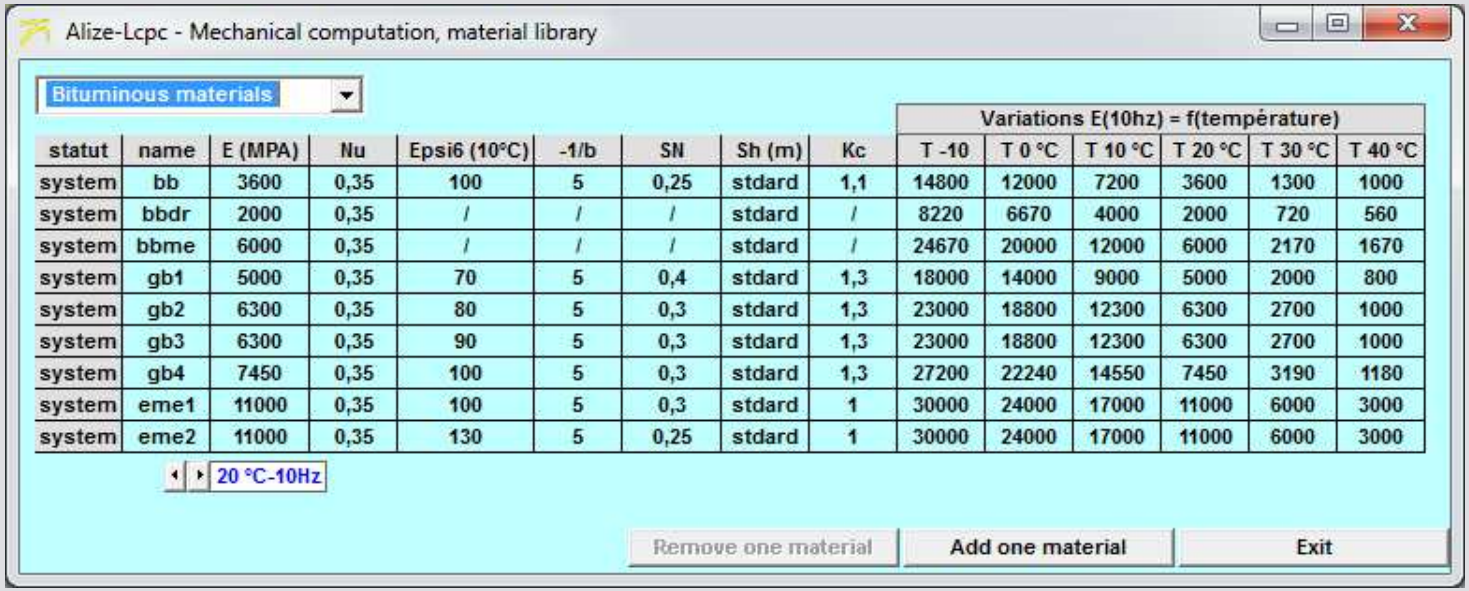
Validé le 20/12/2010 par Jean-Luc GAUTIER

Campus Scientifique et Technique
4, rue Jean Mermoz
78.772 Magny les Hameaux Cedex - France

Prestation n° 101075 - Rapport de prestation — *Page 1 sur 5*

Road Pavement design

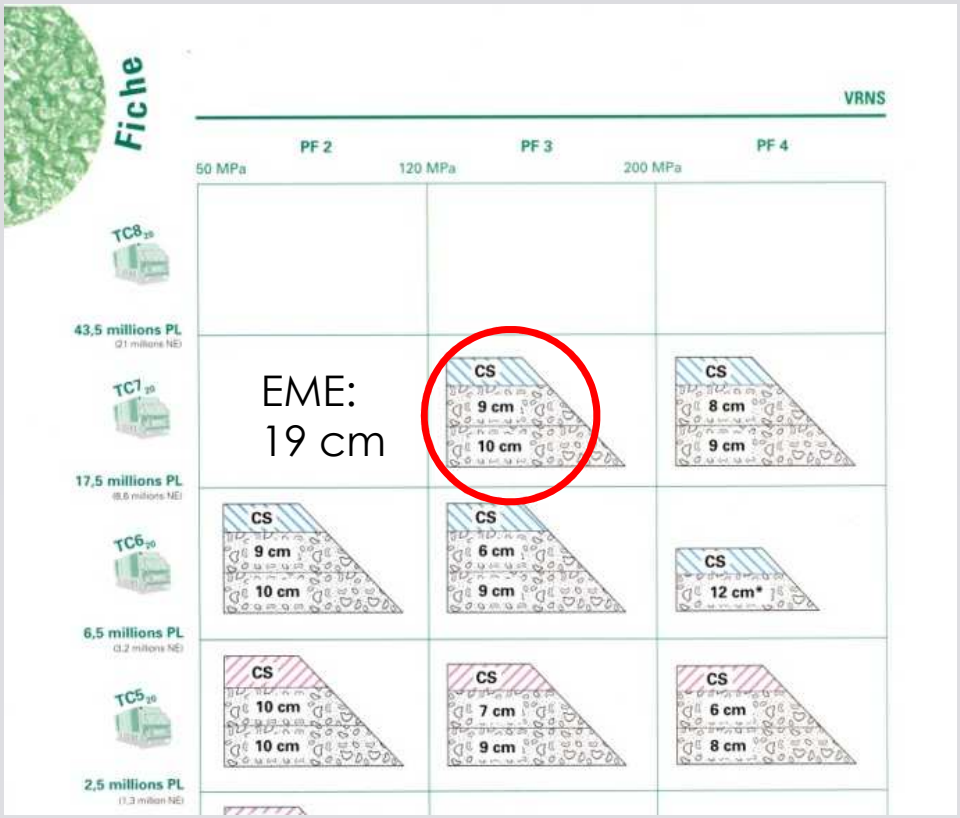
- Modulus Alize Software – Database and update



statut	name	E (MPA)	Nu	Epsi6 (10°C)	-1/b	SN	Sh (m)	Kc	T -10	T 0 °C	T 10 °C	T 20 °C	T 30 °C	T 40 °C
system	bb	3600	0,35	100	5	0,25	stdard	1,1	14800	12000	7200	3600	1300	1000
system	bbdr	2000	0,35	/	/	/	stdard	/	8220	6670	4000	2000	720	560
system	bbme	6000	0,35	/	/	/	stdard	/	24670	20000	12000	6000	2170	1670
system	gb1	5000	0,35	70	5	0,4	stdard	1,3	18000	14000	9000	5000	2000	800
system	gb2	6300	0,35	80	5	0,3	stdard	1,3	23000	18800	12300	6300	2700	1000
system	gb3	6300	0,35	90	5	0,3	stdard	1,3	23000	18800	12300	6300	2700	1000
system	gb4	7450	0,35	100	5	0,3	stdard	1,3	27200	22240	14550	7450	3190	1180
system	eme1	11000	0,35	100	5	0,3	stdard	1	30000	24000	17000	11000	6000	3000
system	eme2	11000	0,35	130	5	0,25	stdard	1	30000	24000	17000	11000	6000	3000

Road Pavement design

- PF3 (Bearing capacity) : 120 Mpa TC6: 17,5 to 43,5 million of « heavy trucks* » t°: 15°C



THICKNESS OF THE BASE COURSE : - 24%

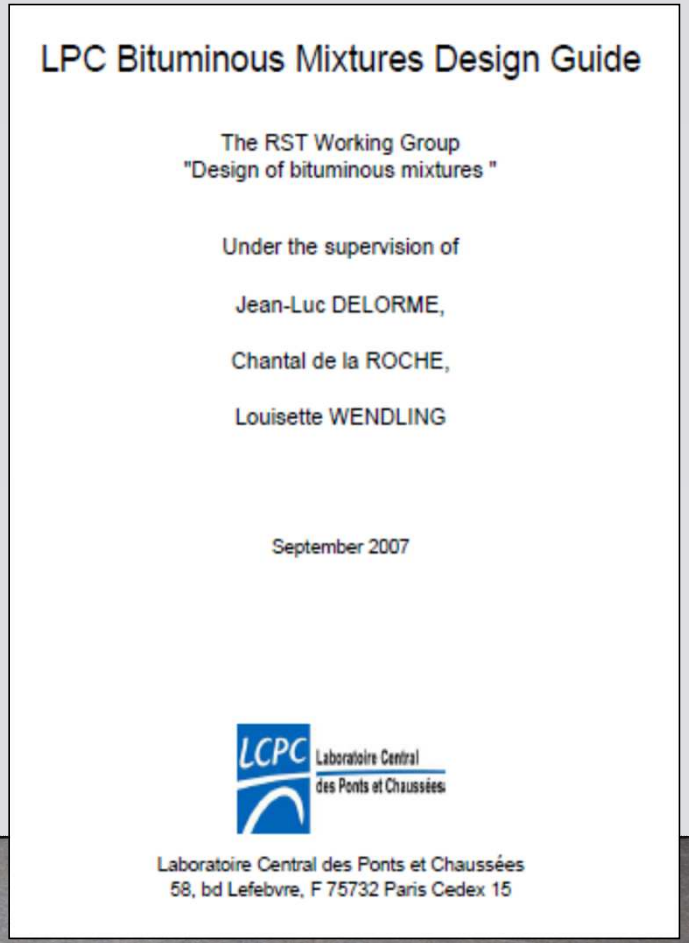
Road Pavement design

- PF3: 120 Mpa TC6: 6,5 to 17,5 ESAL t°: 15°C

	GB3	EME2
15°C	21 cm	15 cm
18°C (Sydney)	22 cm	16 cm
25°C (Mauritius)	24 cm	17 cm
30°C (Bangkok)	26 cm	18 cm

EME Job Mix Formula

- A few words about the fundamental asphalt mix design method according to EN 13108-20
- 4 levels of performance based tests
  - Workability + Water resistance
  - Resistance to permanent deformation
  - Stiffness modulus E*
  - Fatigue resistance ε_6



LPC Bituminous Mixtures Design Guide

The RST Working Group
"Design of bituminous mixtures "

Under the supervision of

Jean-Luc DELORME,

Chantal de la ROCHE,

Louisette WENDLING

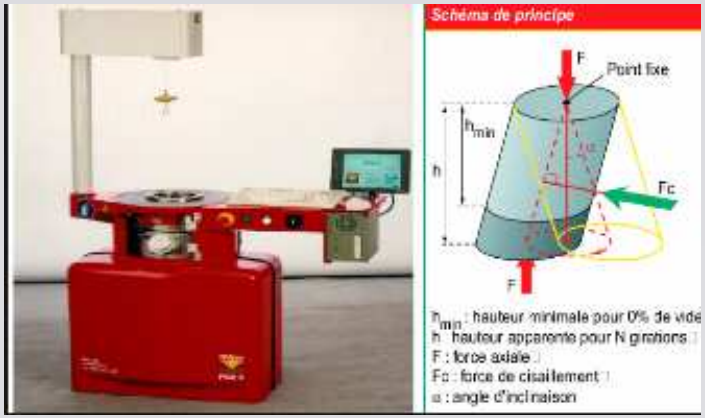
September 2007

LCPC Laboratoire Central des Ponts et Chaussées

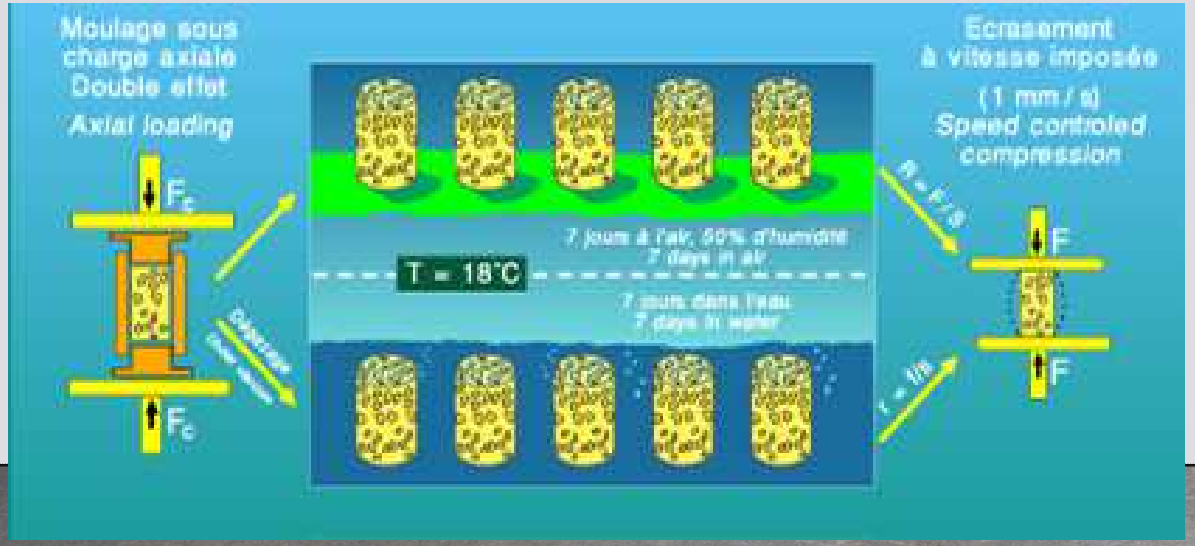
Laboratoire Central des Ponts et Chaussées
58, bd Lefebvre, F 75732 Paris Cedex 15

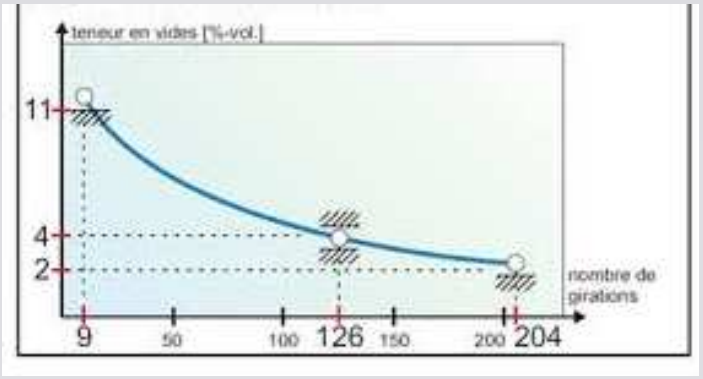
EME Job Mix Formula

- Workability EN 12697-1
  - Giratory compactor Test



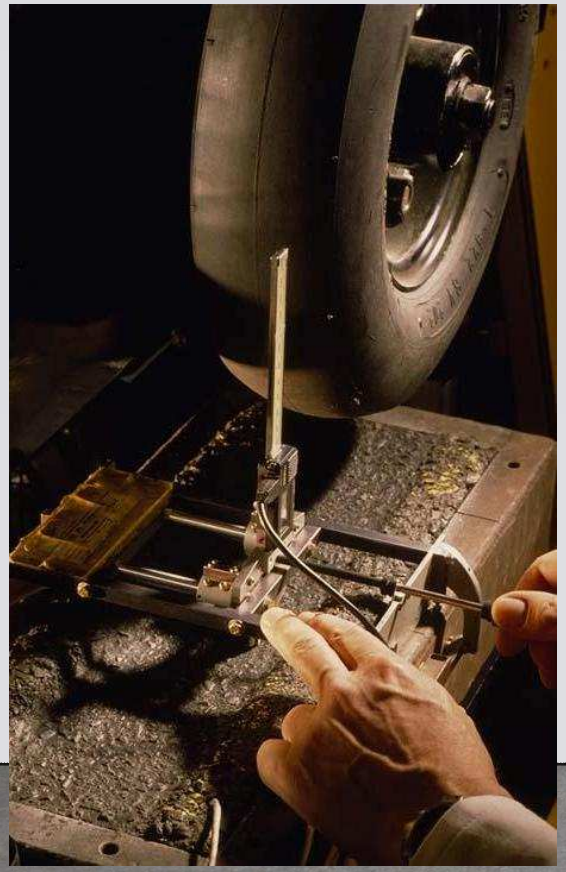
- Water resistance EN 12697-12
  - Compressive strenght on cores after 7 days of immersion

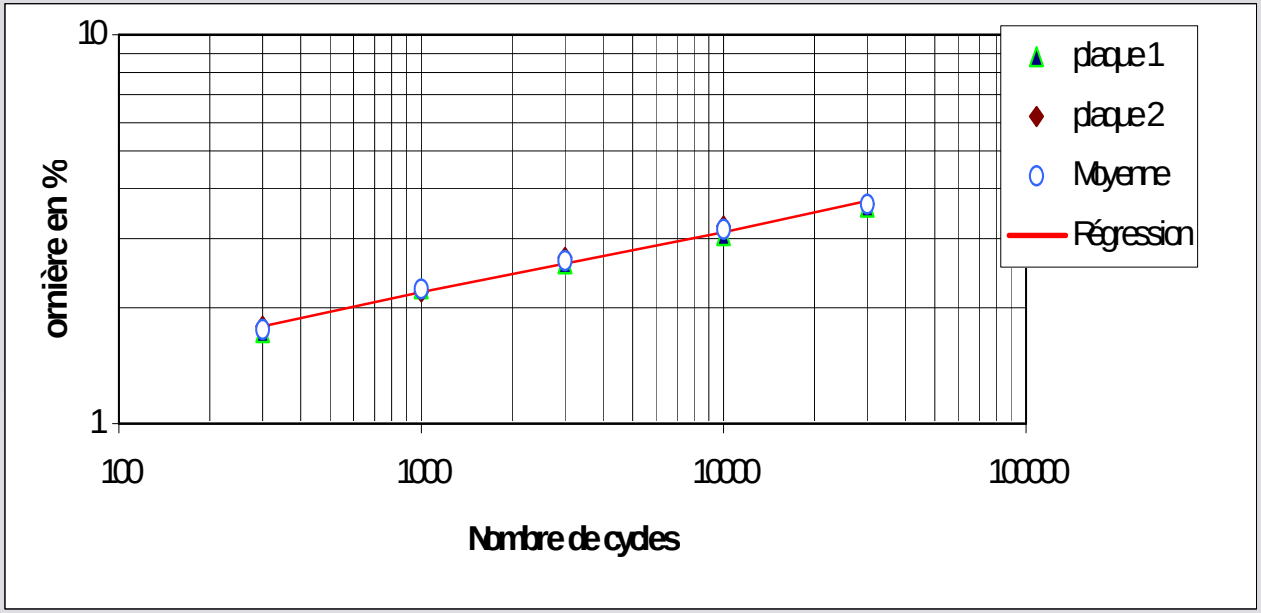




EME Job Mix Formula

- Resistance to permanent deformation : EN 12697-22
  - Determination of rut depth (60°C)

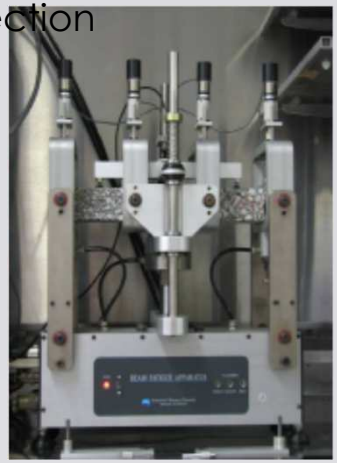




EME Job Mix Formula

- Stiffness modulus (EN 12697-23)
  - Several methods

Sinusoidal dynamic deflection



Impulsion

Direct Tension

Appendix A
15°C 10 Hz
2 PB-TR

Appendix B
20°C 8Hz
3-4 PB-PR

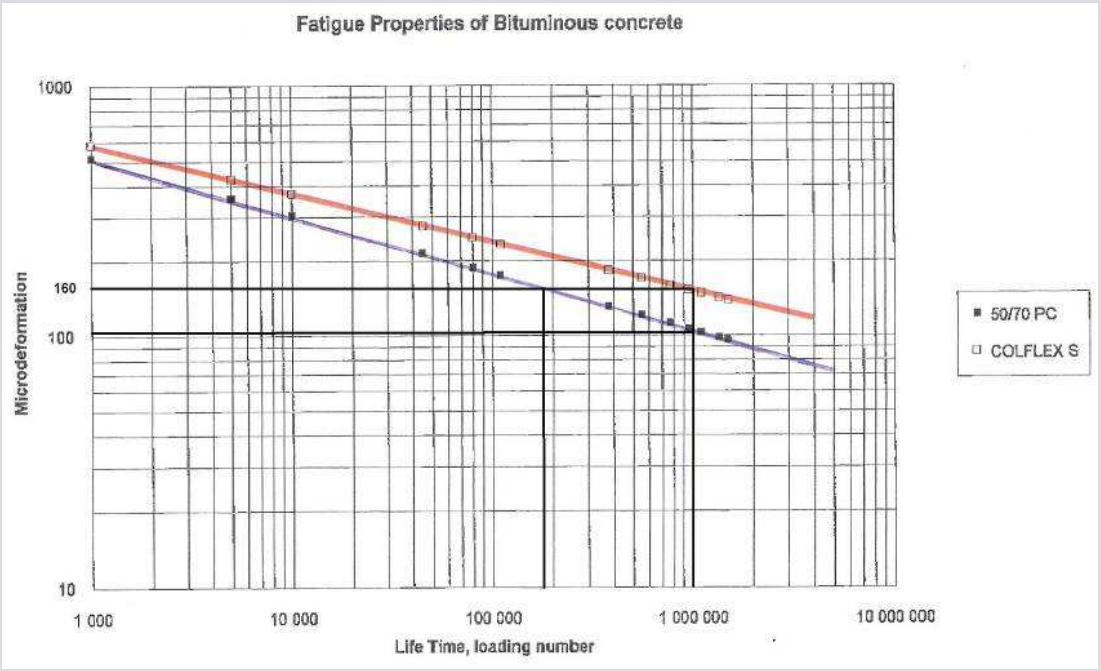
Appendix C
20°C 124ms
IT-CY

Appendix D
15°C 0.02s
DTC-CY

Correlation between value

EME Job Mix Formula

- Fatigue resistance (EN 12697-24)
  - Determination of strain level (fatigue)for 1 million cycles ε_6 (10°C - 25 Hz)

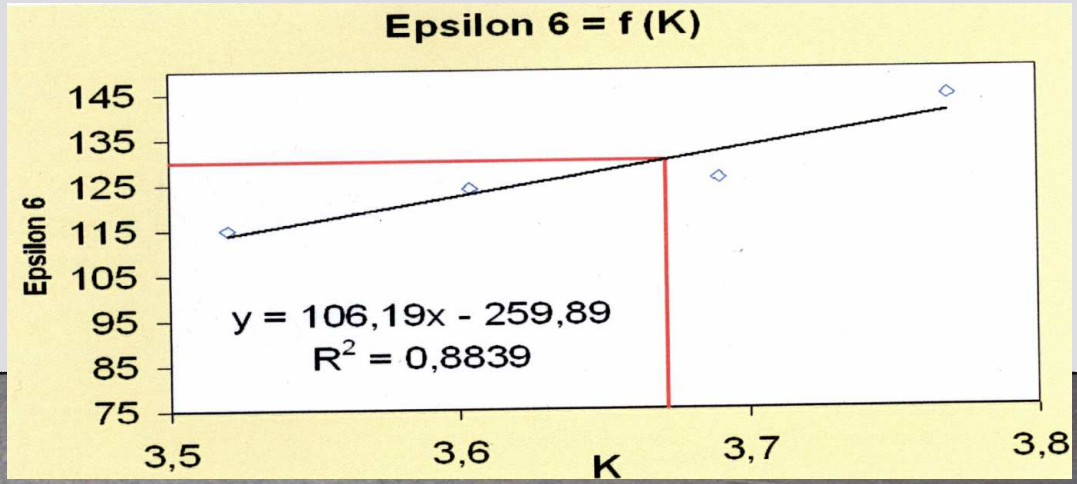


EME Job Mix Formula (1/2)

- An appropriate combination of
  - Aggregates
  - Bitumen
- An appropriate gradation
  - The EN standard does not provide any specification
  - The main aim is to reach a dense mix: void content between 3 & 6% when tested with the gyratory compactor
- An appropriate bitumen…

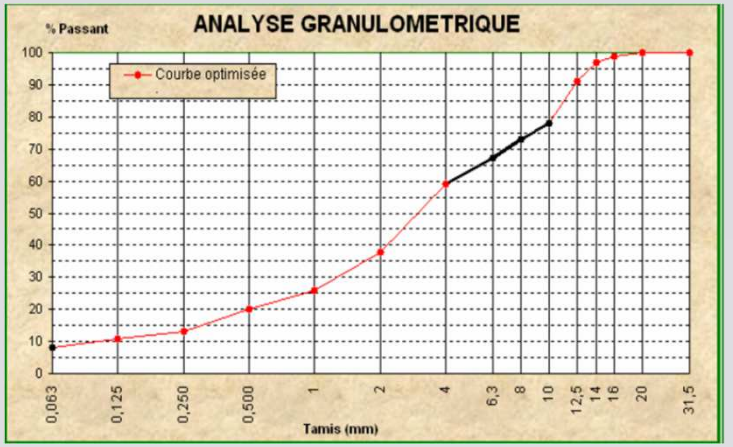
EME Job Mix Formula (2/2)

- The quality of the « hard » bitumen will provide the mix with its modulus (and rutting resistance)
  - **Importance of origin and Production process**
- The quantity of bitumen will provide the fatigue and water resistance
  - **if % bitumen ↗ Fatigue resistance ↗**
    BUT
  - **Stifness Modulus ↘ and Rut ↗**



EME Job Mix Formula

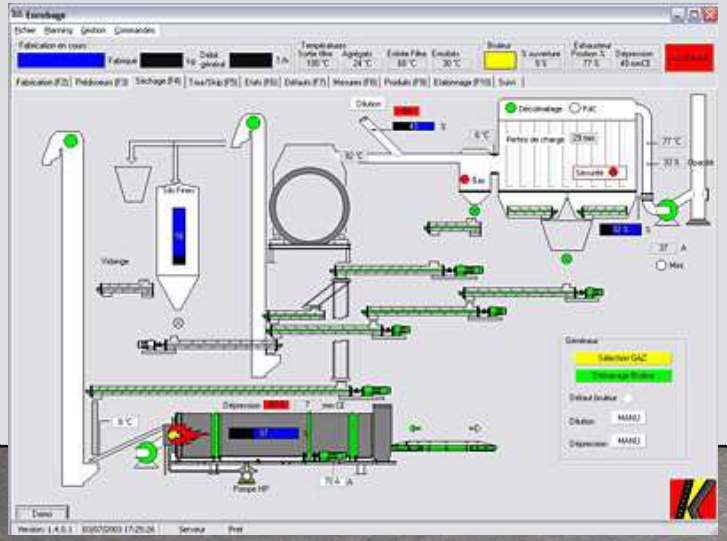
- Optimized grading curve
  - Low Void Content (< 6%)



- Influence of porosity of aggregates on « efficient » bitumen content
- Influence or “cleanlinesse” to avoid the use of “adhesion agent”

Manufacturing

- Nothing very specific compared to conventional asphalt mixes
- Manufacturing temperature: 160 to 180°C (190°C max)
- Control of production within coating plant
  - In case of non-compliance
    - Check the Calibration of bitumen pump (viscosity)
    - Check the calibration of the feeders (optmium point of production)



Specifity and Risks about the EME application

- Richness and deformations
  - **Improvment axis** :keeping material in motion or leave the area because of « punching »

Specifity and Risks about the EME application

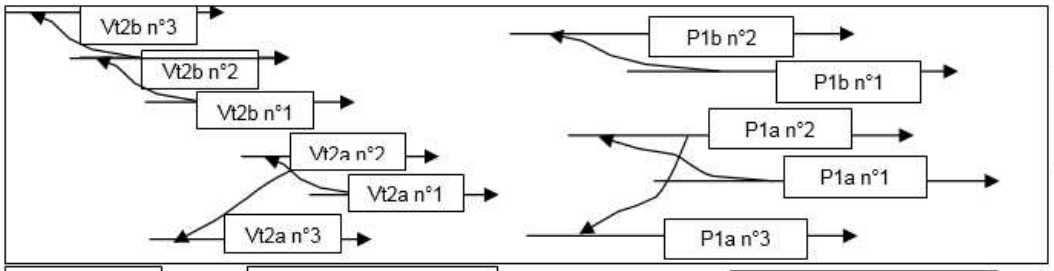
- Richness and high level of compacity
  - Avoid the excess of compaction and bleeding specially when we face superposition of compaction
  - **Improvment axis** Preparation of a « sweeping » pattern Including the « covering » notion

GTOI

SBTPC

Procédure de réalisation des planches d'essai et référence sur EME 0/14 Classe 2 Fondation

PE 4019
Indice n°B
Date d'application :
Page 4 / 7



Low point

L Vt2 = 1.68m
Width of covering = 0.37m

L P1 = 1.92m
Width of covering = 0.35m

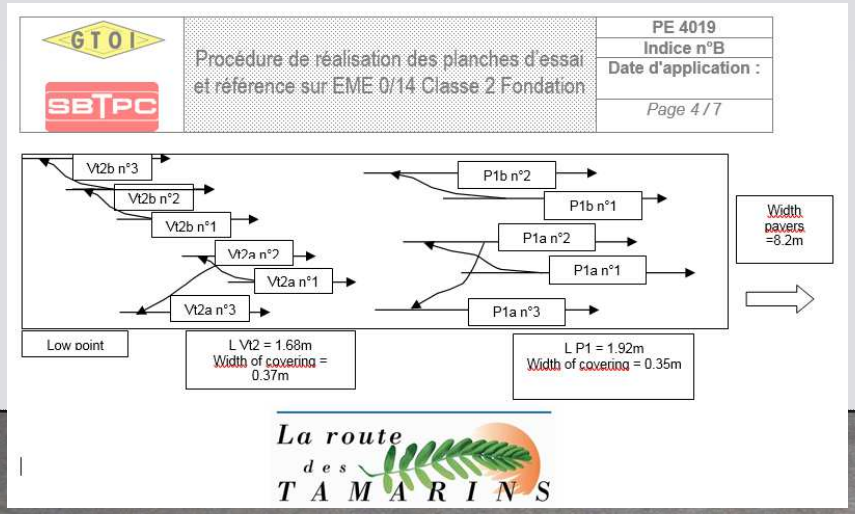
La route des TAMARINS

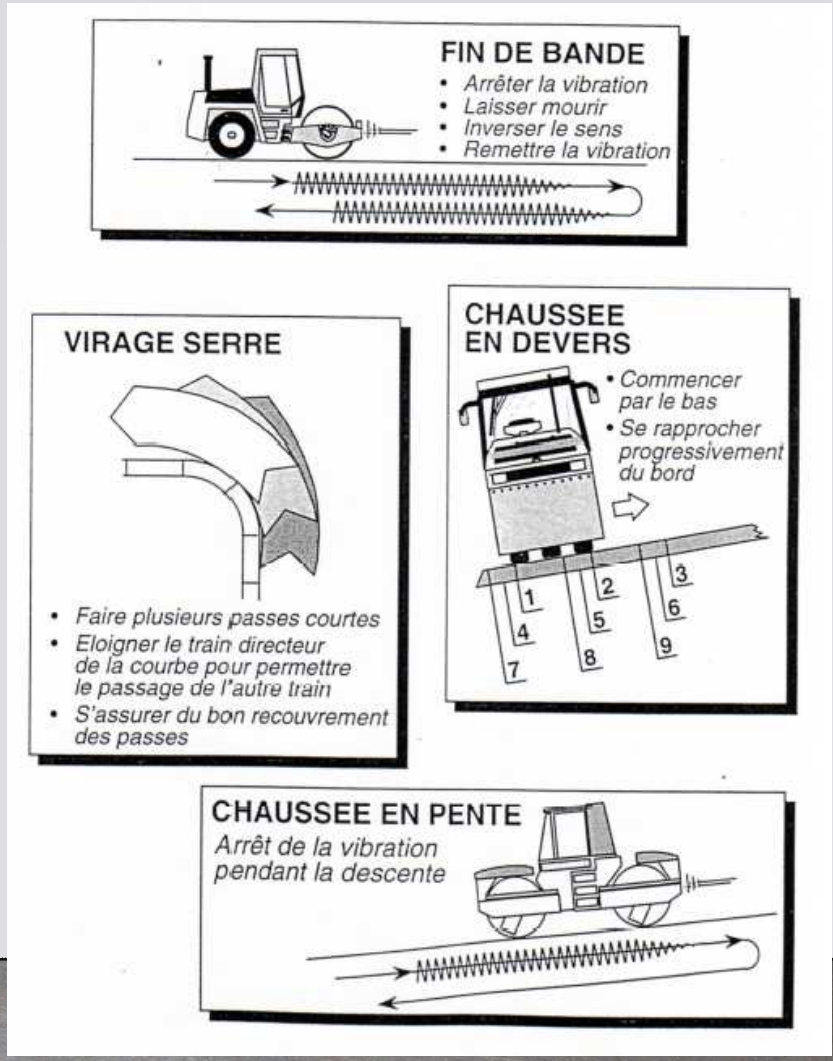
Specifity and Risks about the EME application

- Deep and Surface Compaction rate
  - Avoid the differences of density between the bottom and the upper part of the layer
  - **Advice** Use systematicaly a compaction train with cylinder (vibratory roller) and « multi » (pneumatic tyre roller)

Specifity and Risks about the EME application

- Slope and cracks
  - Advice: stabilisation of the asphalt before the compaction of the edge
  - Advice:Stop the vibration when the compactor is going downhill
  - Advice: compact the curves in several « passes » to limit the shear effect





Specifity and Risks about the EME application

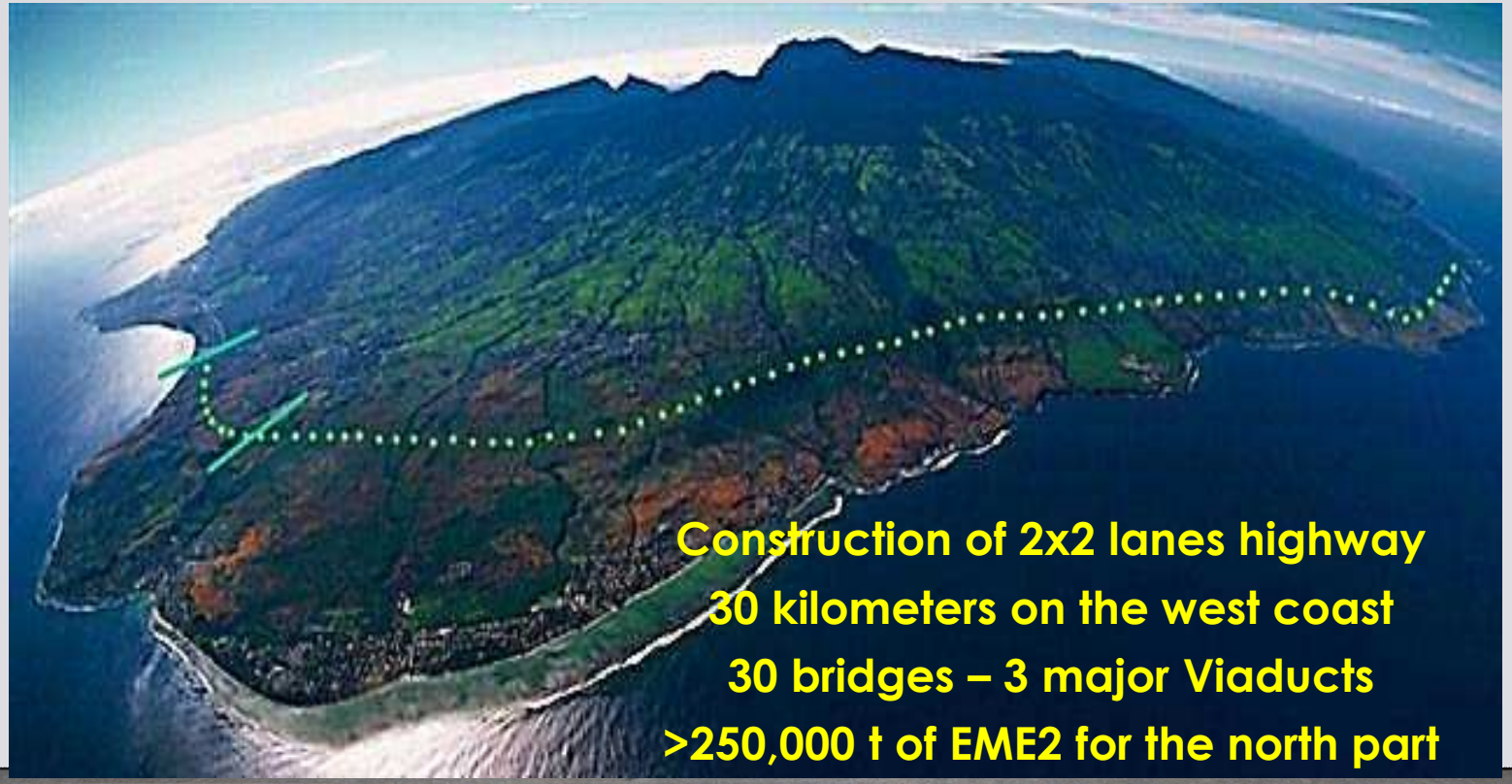
- Wind / Rain and quick loss of temperature
  - Advice: preserve the heat by every mean possible
    - Protection during transport
    - Production adapted to the cadency
    - Protection ot compactors
    - Shorten the compaction train
      - And stop the application in case of degradation …

Quality Control

- Internal Control with Asphalt Plant monitoring system
- External control in laboratory :
  Binder content and grading
- Compaction on site :
  Cores and nuclear gauge

EXAMPLE OF PROJECTS

Tamarind Highway – Reunion Island - 2002 / 2009



Construction of 2x2 lanes highway
30 kilometers on the west coast
30 bridges – 3 major Viaducts
>250,000 t of EME2 for the north part
Total cost : 1,100 M€ (1,600M$)

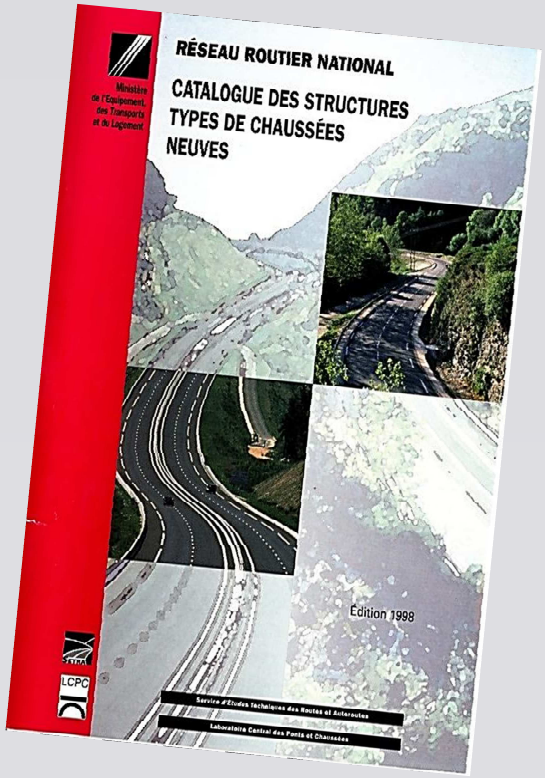
EXAMPLE OF PROJECTS (1/2)

<u>Pavement Structure designed according to French National Road Catalogue :</u>

French and European Standards applicable locally

Preliminary studies for base course :
24 cm "Traditional GB3"

Optimized final structure
(30 years–18.5 M axle load/y) :19 cm EME2



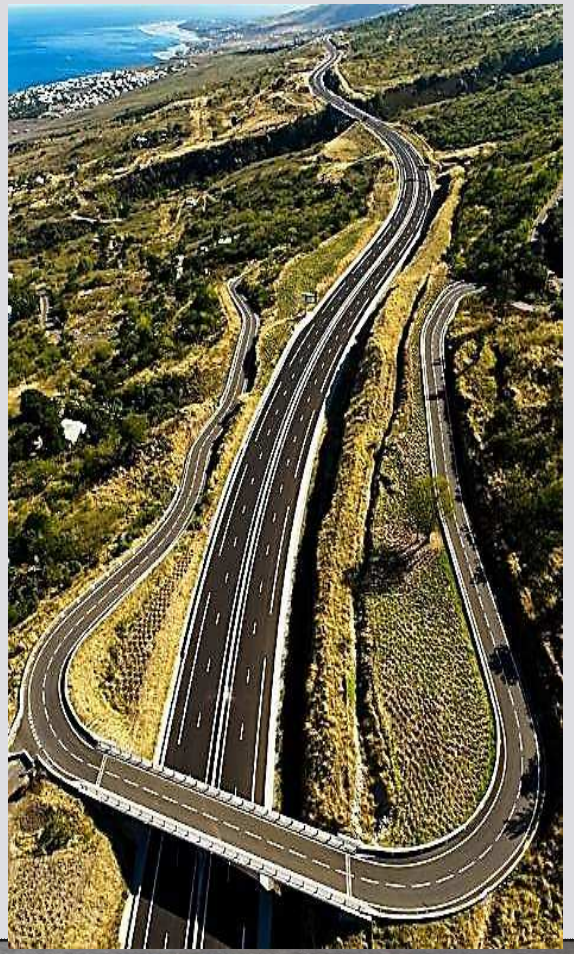
EXAMPLE OF PROJECTS (2/2)

Climatic aspects :

20°C local reference temperature
≠ 15°C used in Metropolitan France

Complex modulus for EME2 :
11 500 MPa instead of 14 000 MPa

Impact on thickness :
+1 cm EME2 on base courses



Conclusion

How to promote EME:

First

- Use strict Pavement Design method
- Consider Local (load) and climatic conditions

Then :

- Implement EME2 characteristics in Design Method
- Find the adequate binder
  - crucial because of affinity and regularity issues
- Perform comparative tests
  - Compulsory in qualified Laboratory