L'exploitation
et la maintenance
des infrastructures

PN - ANR MOVE
DVDC
DURÉE DE VIE DES CHAUSSÉES

IREX
Institut pour la recherche appliquée et l'expérimentation en génie civil

Theme 1 - Deterioration mechanisms
1.2 – Bearing soil & flexible road pavements

Summary of international methods for designing flexible road pavements and unpaved roads

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Public presentation of results
7 November 2023, ENTPE, Vaulx-en-Velin

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▶ Composition of the study (3 parts)

- **Part one** – summary of flexible road pavement methods
  - empirical methods,
  - analytical methods,
  - catalogues of typical structures.
- **Part two** – summary of unpaved road methods

Objective: literature review

- brief descriptions of the methods,
- consideration of the soil,
- consideration of granular materials.

Total: 12 design methods



Composition of the study

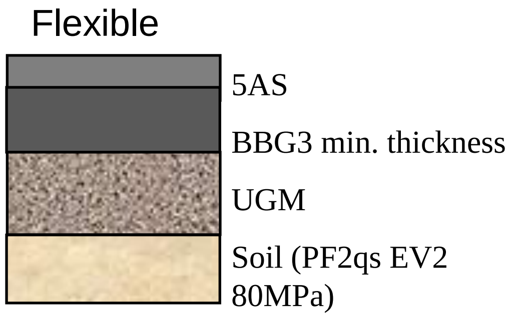
Part three

- 3 more methods
  - Analysis of the Belgian method (analytical method);
  - Analysis of the German method (catalogue of structures);
  - Analysis of the Japanese method (empirical method).

Objective:

- Create a summary table containing information such as: reference axles, UGM characterisation, climate, risks/uncertainties, design duration, etc.

- Comparative example
  - 8 methods:
    - » Guides: French, AASHTO, DRMB, Canada, Japan
    - » Catalogues: Spanish, German, Senegal
  - Assumptions:
    - » Typical Structure:



- » Service life: 20 years
- » Maximum traffic: 250,000 HGV

Objective: Use different methods to calculate equivalent structures



► The references used

No.	Method	Reference
[1]	Road Note 31	Transport Research Laboratory Road note 31 - A guide to the structural design of bitumen surfaced roads in tropical and sub-tropical countries-1993*
[2]	CEBTP	CEBTP - Practical guide for designing road pavements for tropical countries (*Guide Pratique de dimensionnement des chausses pour les pays tropicaux*) - new 1984*
[3]	Australian	AUSTROADS Part 2 2012*
[4]	American	AASHTO guide for design of pavements structures, American Association of State Highway and Transportation Officials, 1993 (and 1998 for rigid pavement)
[5]	English	DMRB Design Manual for Roads and Bridges – Highways Agency, Volume 7, Section 2, Part 3 – HD 26/06, + Part 1 – Traffic Assessment - HD 24/06, February 2006.
[6]	Algerian	Catalogue of designs for new road pavements by the National Body for Technical Inspection of Public Works *(Catalogue de Dimensionnement des Chaussées Neuves de l'Organisme National de Contrôle Technique des Travaux Publics*) (CTTP) Algeria 2000
[7]	French	French standard NF P 98-086, Structural design of road pavements (*Dimensionnement structurel des chaussées routières*) 2011
[8]	South African	South Africa SATCC – July 2001 – Code of Practice for the Design of Road pavements – draft*
[9]	Tanzanian	Tanzania – pavement and materials design manual – 1999*
[10]	Viziret	Viziret Qualification and quantification of deteriorations to an unpaved road for the programming and monitoring of maintenance work (*Viziret qualification et quantification des dégradations d'une route non revêtue pour la programmation et le suivi des travaux d'entretien*) – Bulletin des Laboratoires des Ponts et Chausses No. 213 1998.
[11]	Spanish	Spanish road pavement structure catalogue – norma 6.1 IC secciones de formes*
[12]	Senegalese	Catalogue of new road structures and Road sizing guide in Senegal (*Catalogue de structures de chaussées neuves et Guide de dimensionnement des chaussées au Sénégal*) - 2015



▶ Empirical methods

- Approach: parameters are defined based on observations
- Detailed analysis (general points, advantages, disadvantages): AASHTO, DMRB

▶ AASHTO EXAMPLE - M_R

- Soil taken into account with the M_R characteristic, the reversible modulus,
- Characteristic that quantifies the stiffness of a soil,
- Characteristic can change during the different seasons of the year, especially during the frost period,



► Example – AASHTO method

Table 1

Models linking the indices and strength properties of certain materials to the reversible modulus M_r

Strength/Index Property	Model	Comments	Test Standard
CBR	$M_r = 2555(CBR)^{0.64}$	CBR = California Bearing Ratio, percent	AASHTO T193—The California Bearing Ratio
R-value	$M_r = 1155 + 555R$	R = R-value	AASHTO T190—Resistance R-Value and Expansion Pressure of Compacted Soils
AASHTO layer coefficient	$M_r = 30000\left(\frac{a_i}{0.14}\right)$	a_i = AASHTO layer coefficient	AASHTO Guide for the Design of Pavement Structures (1993)
PI and gradation*	$CBR = \frac{75}{1+0.728(wPI)}$	wPI = P200*PI P200= percent passing No. 200 sieve size PI = plasticity index, percent	AASHTO T27—Sieve Analysis of Coarse and Fine Aggregates AASHTO T90—Determining the Plastic Limit and Plasticity Index of Soils
DCP*	$CBR = \frac{292}{DCP^{1.12}}$	CBR = California Bearing Ratio, percent DCP =DCP index, in/blow	ASTM D6951—Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications

*Estimates of CBR are used to estimate M_r.

Source : AASHTO (2002).



▶ Analytical methods

- Criterion: check that the actual stresses (related to the passage of a reference load) remain less than the admissible values for a given number of cycles,

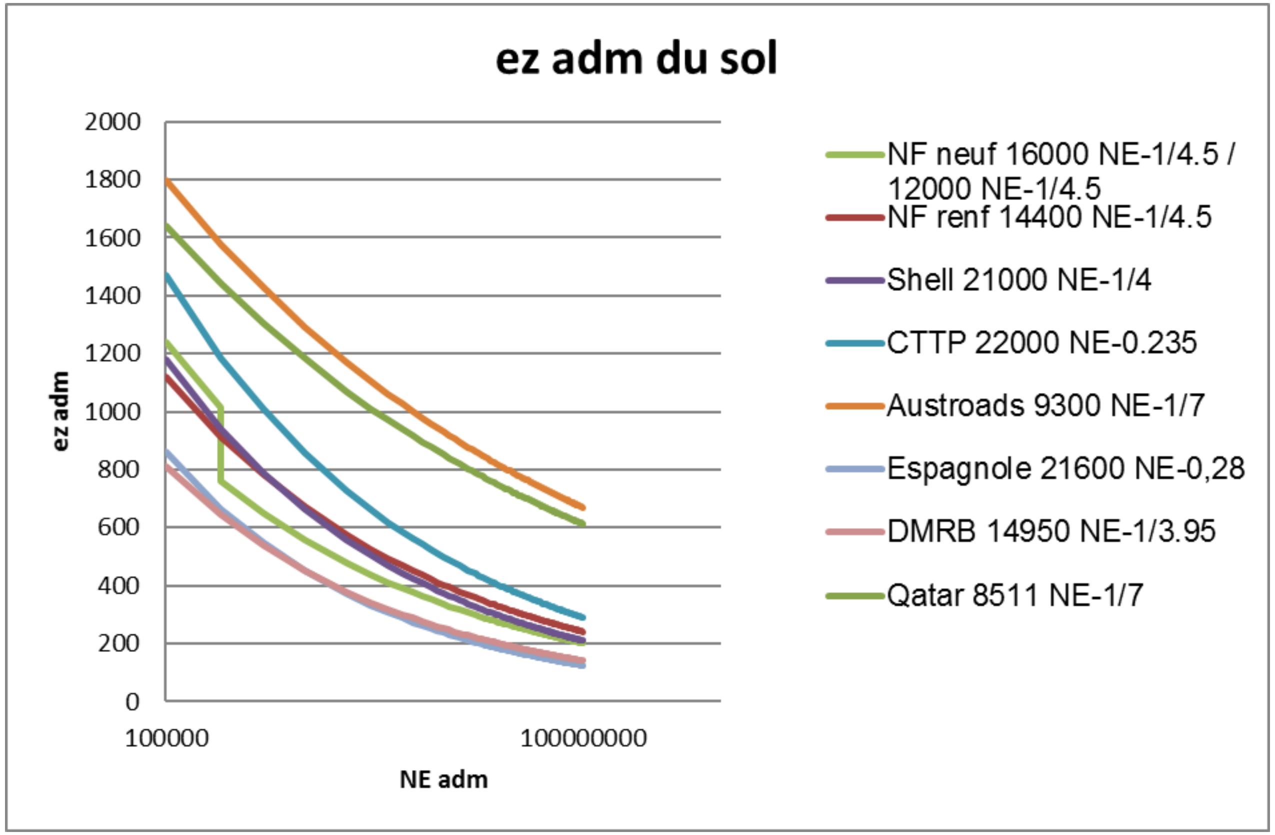
- The methods do not necessarily contain the concept of a flexible road pavement,

- Probabilistic: taking into account the dispersion and random nature of the various factors (characteristics of the materials, thickness of the course), calculation risk, etc.



- Allowed vertical deformation at the top of the soil:
  - Méthode Austroads : $\varepsilon_{z\ adm} = 9300\ NE^{-0,142}$
  - DMRB : $\varepsilon_{z\ adm} = 14\ 950\ NE^{-0,253}$
  - Catalogue d'Algérie $\varepsilon_{z\ adm}$ seul pour structure souple = $22\ 000\ NE^{-0.235}$
  - Méthode française et le Catalogue du Sénégal:
    - Faible trafic NE ≤ 250 000 : $\varepsilon_{z\ adm} = 16\ 000\ {}^*NE^{-0,222}$;
    - Fort trafic NE ≥ 250 000 : $\varepsilon_{z\ adm} = 12\ 000\ {}^*NE^{-0,222}$
  - Viziret : $\varepsilon_{z\ adm} = 21000\ NE^{-0,25}$ pour 85% fiabilité
  - Catalogue espagnol : $21600\ NE^{-0,28}$
  - Méthode Belge :
    - Sol : $\varepsilon_{z\ adm} = 1.1 \times 10^{-2} \times NE^{-0,23}$

- Different levels of E_z depending on the type of method used





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Conclusions parts 1 and 2

- Empirical methods are based on observations and are therefore more difficult to adapt to a new environment,
- Rational methods take into account a large number of parameters => a theoretical knowledge of the method is necessary,
- For certain empirical methods and catalogues, episodic revision seems desirable to take into account new theoretical and technical knowledge and new observations of the actual behaviour of the sections,
- It is essential to incorporate local experience into the estimate,
- **The influence of climatic phenomena** (duration and frequency of rainy periods, freezing-thawing) **is not systematically incorporated into the design**.
- **There is significant variation in moduli and deformations depending on the methods used**



► Considerations on the methods used for the comparison

Method	Reference axle	Temperature / Materials / Subgrade	Design time
Alizé (FR)	13t	TRef 15°C / Roadbed bearing capacity	20
AASHTO	8.16t	TRef 20°C / Roadbed CBR	20
Japanese guide	5t	Characterization of materials by Marshall/CBR stability	10 (but possibility of taking into account a different duration)
DMRB Guide	8.16t reference axle; Reference temperature = 20°C; Dissociation of CBR and subgrade class; granular materials are not counted as a road pavement course	TRef 20°C / CBR	20
Canadian Guide	8.16t	TRef by Region: 20.5°C north and 17.5°C south / CBR	25
Spanish catalogue	13t	TRef 20°C / CBR / Bearing capacity	20
German catalogue	10t	Not mentioned / Bearing capacity	20
Senegal catalogue	13t	TRef 34°C / Bearing capacity	10 to 30 (depending on the network) but more often 20 years

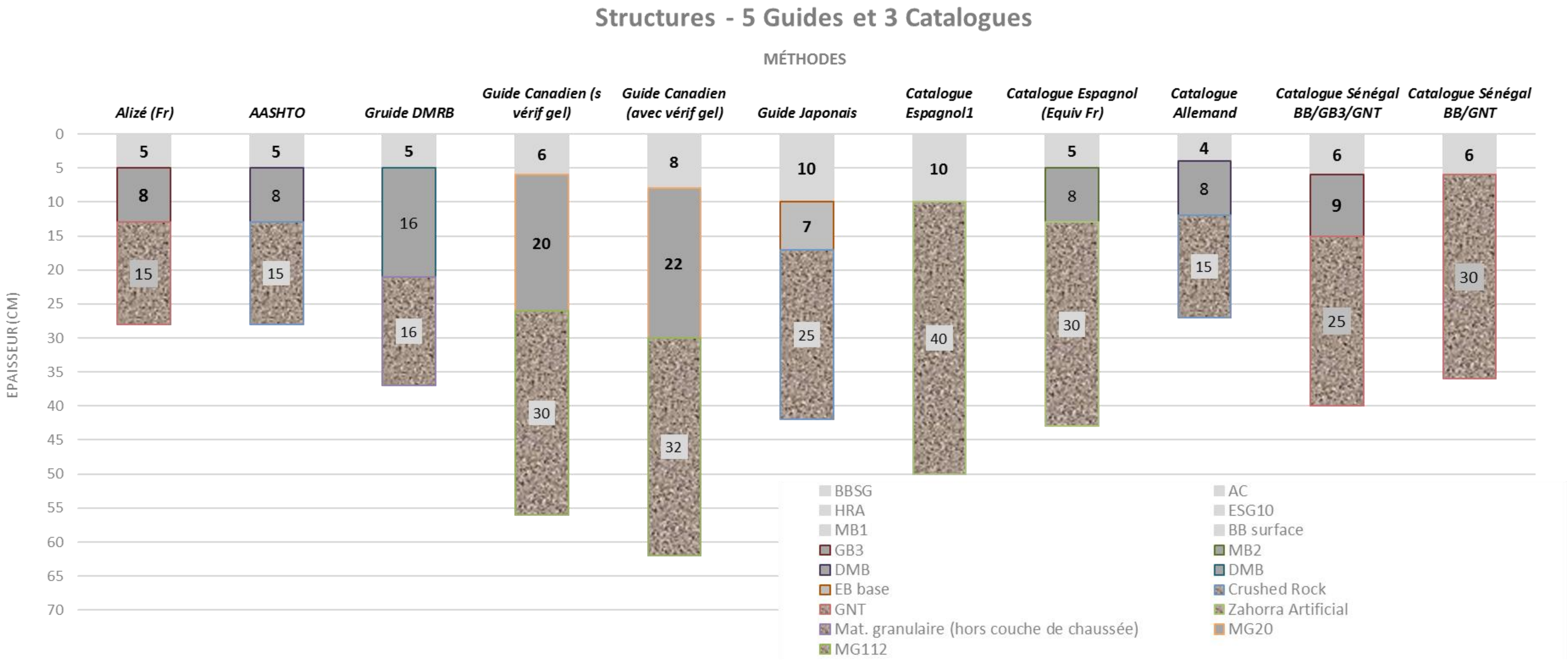
Reference Method:
French method (NF 98 086):

- Wearing course:
  SCAS Cl2, 7000 MPa (15°C, 10Hz)
- Base course: BBG Cl3
- UGM sub-base
- Roadbed: 80 MPa
- Service life: 20 years;
- Maximum traffic: 250,000 HGV
- T4 traffic
- NE: 0.075×10^6

Structure: 5SCAS CL2 + 8BBG3 + 15UGM



► Road pavement structures using the selected methods





▶ Conclusions Part 3

- The main variations in thickness are observed in countries with much harsher winters than France. The greatest thickness was obtained with the Canadian Guide

- The characteristics of the materials also have an influence on thickness

- The catalogues also show differences due to the fact that they are assigned to a traffic class