GDAŃSK UNIVERSITY OF TECHNOLOGY

POLISH APPROACH TO PAVEMENT DESIGN

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OUTLINE

- Introduction
- Terminology and structure
- Traffic, Materials, Subgrade, Lower layers and improved subgrade
- Calculations of upper layers
- Results – new structures compered to other catalogues

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Introduction

- Till now we have no Polish M-EPD method
- Since 1977 (1982) we have used catologue based on EPD method
- From the late 90's we have used M-EPD methods (criteria: AI, Shell, Nottingham, BCRR, South Africa, French etc.)
- Since 1997 (2014) we have used catologue based on M-EPD method

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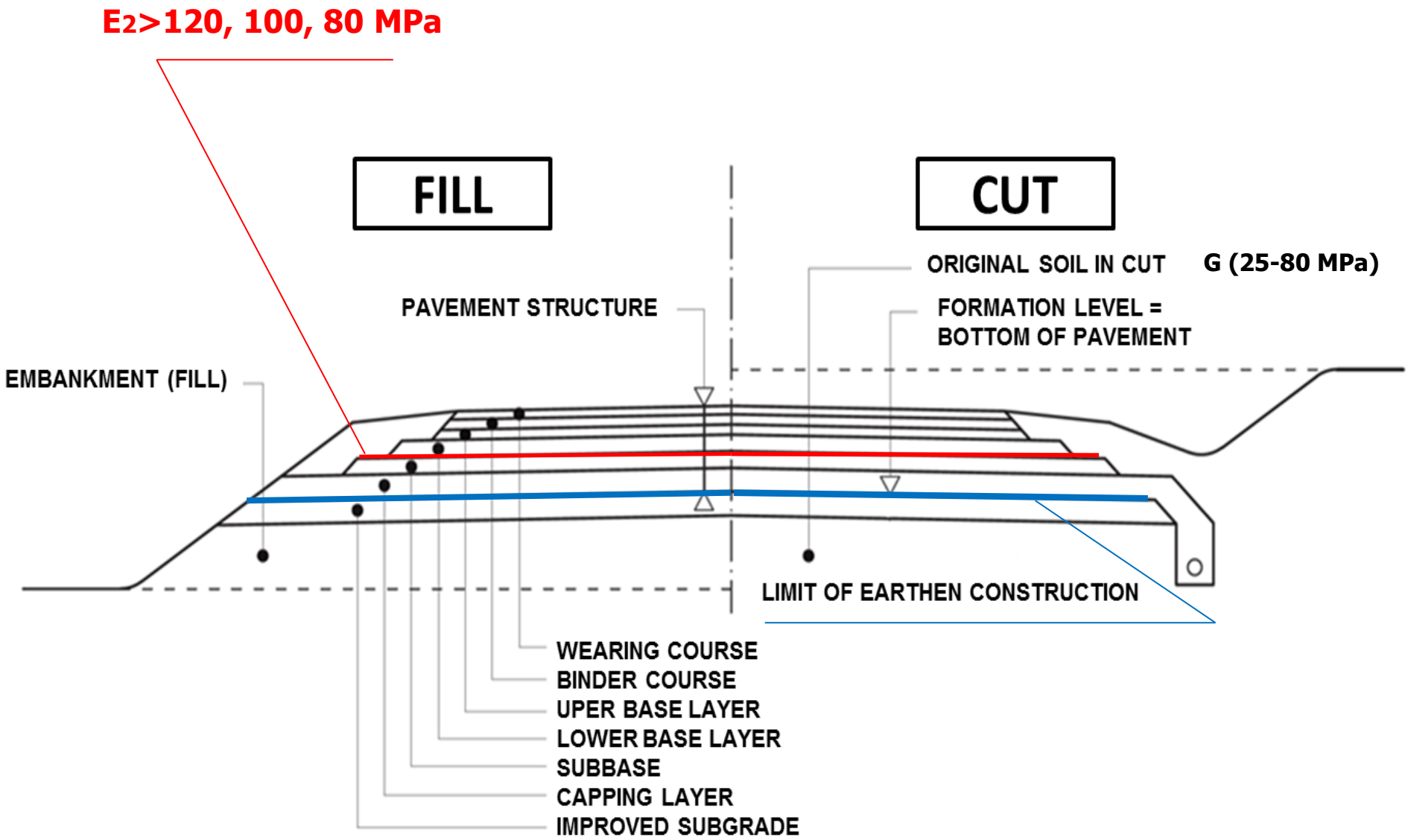
PAVEMENT STRUCTURE



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TRAFFIC

- Design life period
  - 30-years for motorways and expressways
  - 20-years for other roads (national, district, local)
- Two classes of allowed load
  - 115 kN – motorways, expressways and national
  - 115 kN or 100 kN other roads – temporarily period
- Equivalent Single Axle Load – 100 kN
  - New equivalency factor: HGV without and with trailer, coaches&buses based on analys from WIM station
  - Factors accounting: lane width and number of lanes, longitudinal gradient
- 7 categories of traffic (KR1-30,000 to KR7-90,000,000 ESAL)

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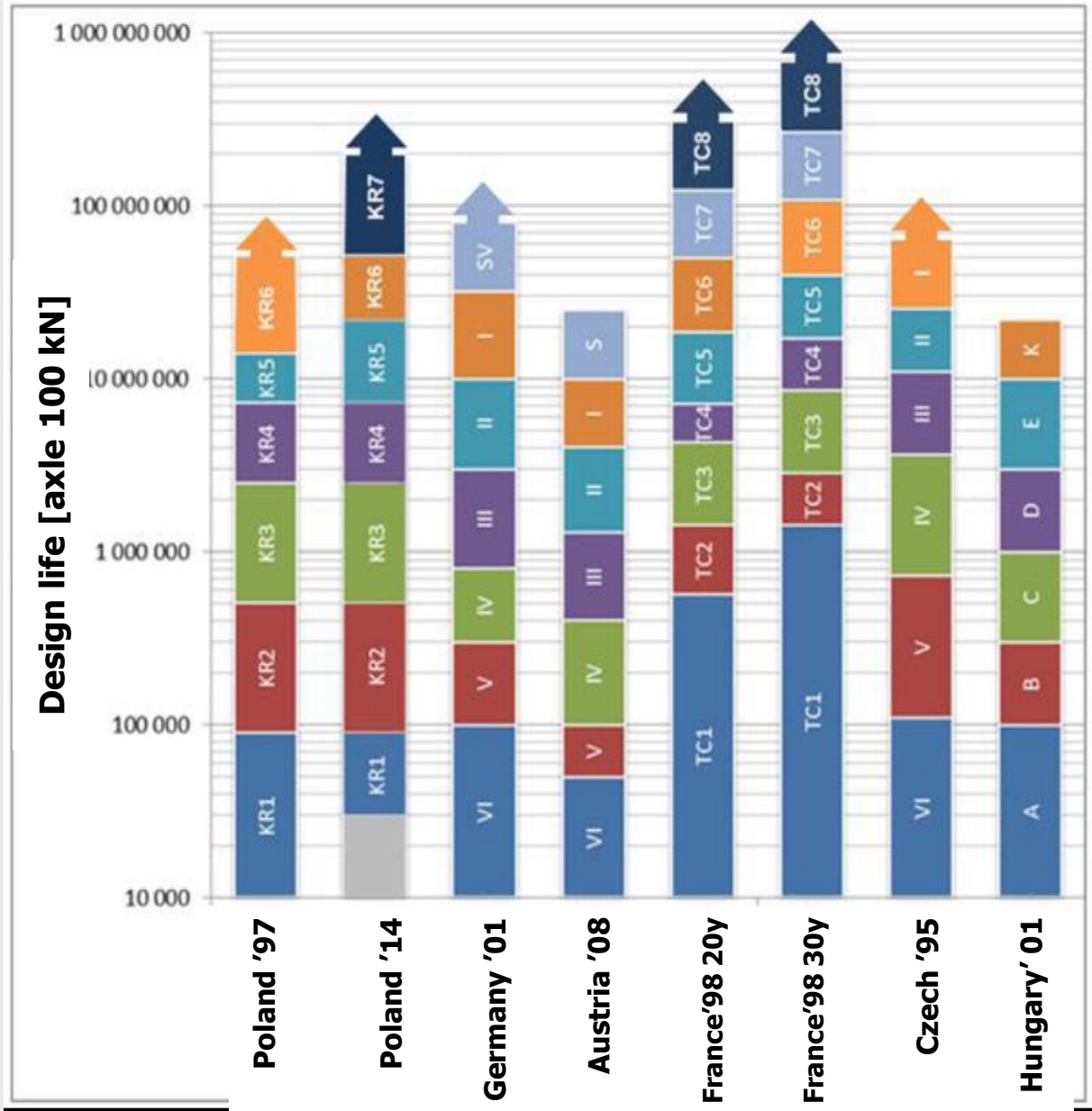
TRAFFIC

Design life:
-all standardized to 100 kN
-20 or 30 years



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MATERIALS

- **Wearing course:** SMA, AC, PA, BBTM
- **Upper base and binder course:** AC (HMAC not included)
- **Lower base course:**
  - Unbound aggregate mixture (**UM**): $C_{90/3}$, $C_{50/30}$, C_{NR}, CBR>80 or 60%
  - Hydraulically bound mixture (**HBM**): $C_{8/10}$, $C_{5/6}$, $C_{3/4}$
  - Hydraulically treated soil (**HTS**): $C_{3/4}$, $C_{1,5/2}$
  - Cold recycling mixture (cement +bitumen emulsion or foam bitumen)

MATERIALS (2)

- **Subbase:** UM C_{NR}, CBR>60%, HBM and HTS $C_{5/6}$, $C_{3/4}$, $C_{1,5/2}$
- **Capping layer** – frost layer or drainage layer: HBM or HTS $C_{1,5/2}$, UM CBR>35 or 25% or in case of drainage layer UM, soil n.s.f.h.
- **Improved subgrade:** UM CBR>20%, soil n.s.f.h., HTS $C_{0,4/0,5}$

- n.s.f.h.: non sticky/firm/hard

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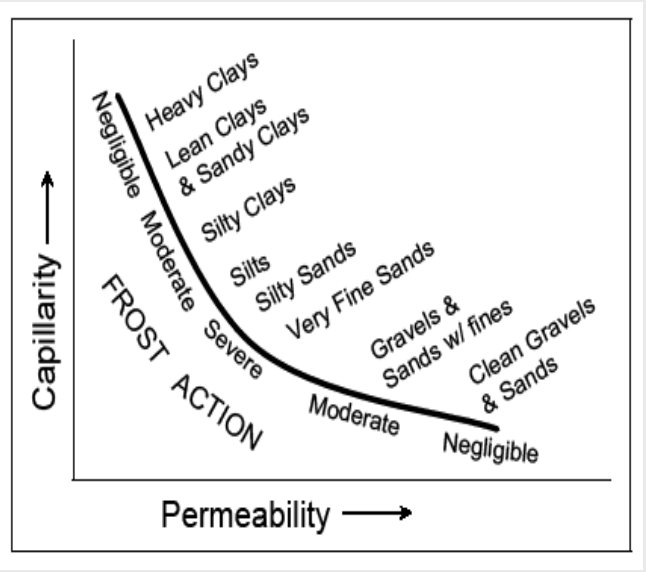
SUBGRADE

- 4 subgrade classes-groups: G1, G2, G3 i G4
- Subgrade classified by bearing capacity: CBR → in situ static plate modulus E_2 and by frost susceptibility

Lp.	Subgrade group Gi	CBR after 4 days soaking [%]	Static plate modulus E2 [MPa]
1	2	3	4
1.	G1	CBR ≥ 10	$E_2 \geq 80$
2.	G2	5 ≤ CBR < 10	$50 \leq E_2 < 80$
3.	G3	3 ≤ CBR < 5	$35 \leq E_2 < 50$
4.	G4	2 ≤ CBR < 3	$25 \leq E_2 < 35$



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CALCULATION

1. Mechanistic criteria (IA’81, AASHTO’04, F’94, Shell’77)
2. Empirical method - AASHTO ’93
3. Catalogues
   - Austria ’08
   - Germany ’01
   - Poland ’97
   - UK method ’06
   - France ’98

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CALCULATION (2)

- AASHTO 2004 – main criterium (bottom-up cracking)
  - FC=5, 10, 15 i 20%
- IA, Shell – only for comparison
- F – only for HMAC (finally not included)
- University of Illinois (Dempsey) – for semi-rigid
- PCA – for semi-rigid

AASHTO fatigue criterium

$$N_f =$$

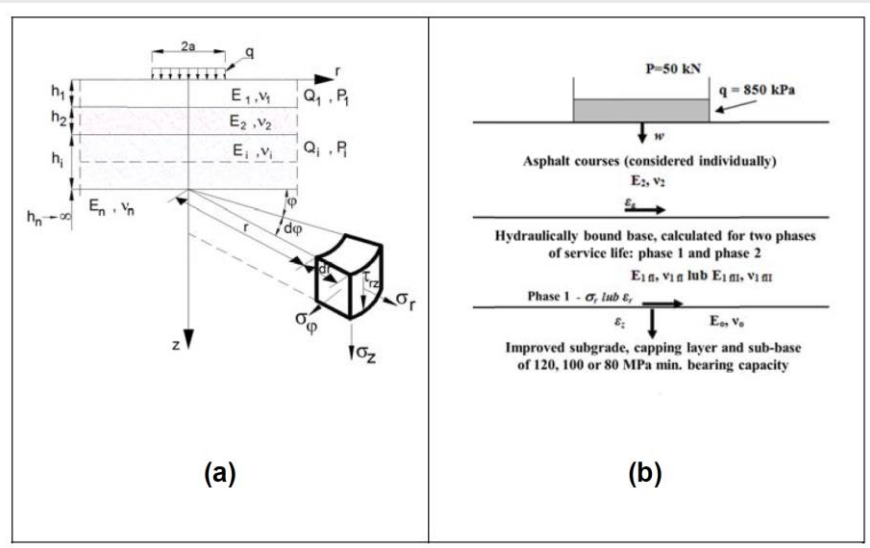
$$D * 7{,}3557 * (10^{-6}) \cdot C \cdot k'_1 \left(\frac{1}{\varepsilon_t}\right)^{3{,}9492} \left(\frac{1}{E}\right)^{1{,}281}$$

$$C = 10^{M}$$

$$M = 4{,}84\left(\frac{V_b}{V_a + V_b} - 0{,}69\right)$$

$$k'_1 = \frac{1}{0{,}000398 + \frac{0{,}003602}{1+e^{(11{,}02-1{,}374\cdot h_{ac})}}}$$

$$FC_{bottom} = \left(\frac{100}{1+e^{(-2\cdot C\prime_2 + C\prime_2 \cdot log_{10}(D\cdot 100))}}\right)$$



deformation criterium

- $N_p = \left(\frac{\varepsilon_z}{0{,}0105}\right)^{\left(-\frac{1}{0{,}223}\right)}$

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CALCULATION ASSUMPTIONS

1. Mechanistic calculation of upper pavement layers for support level of 120, 100 and 80 MPa, depending on the traffic class KR
   - solutions for lower pavement layers and improved subgrade were calculated earlier
2. Accepted results
   - according to AASHTO 2004
3. Comparison of accepted results with other catalogues
4. Implementation of technological tolerances for asphalt layers (+1 cm for asphalt layers)

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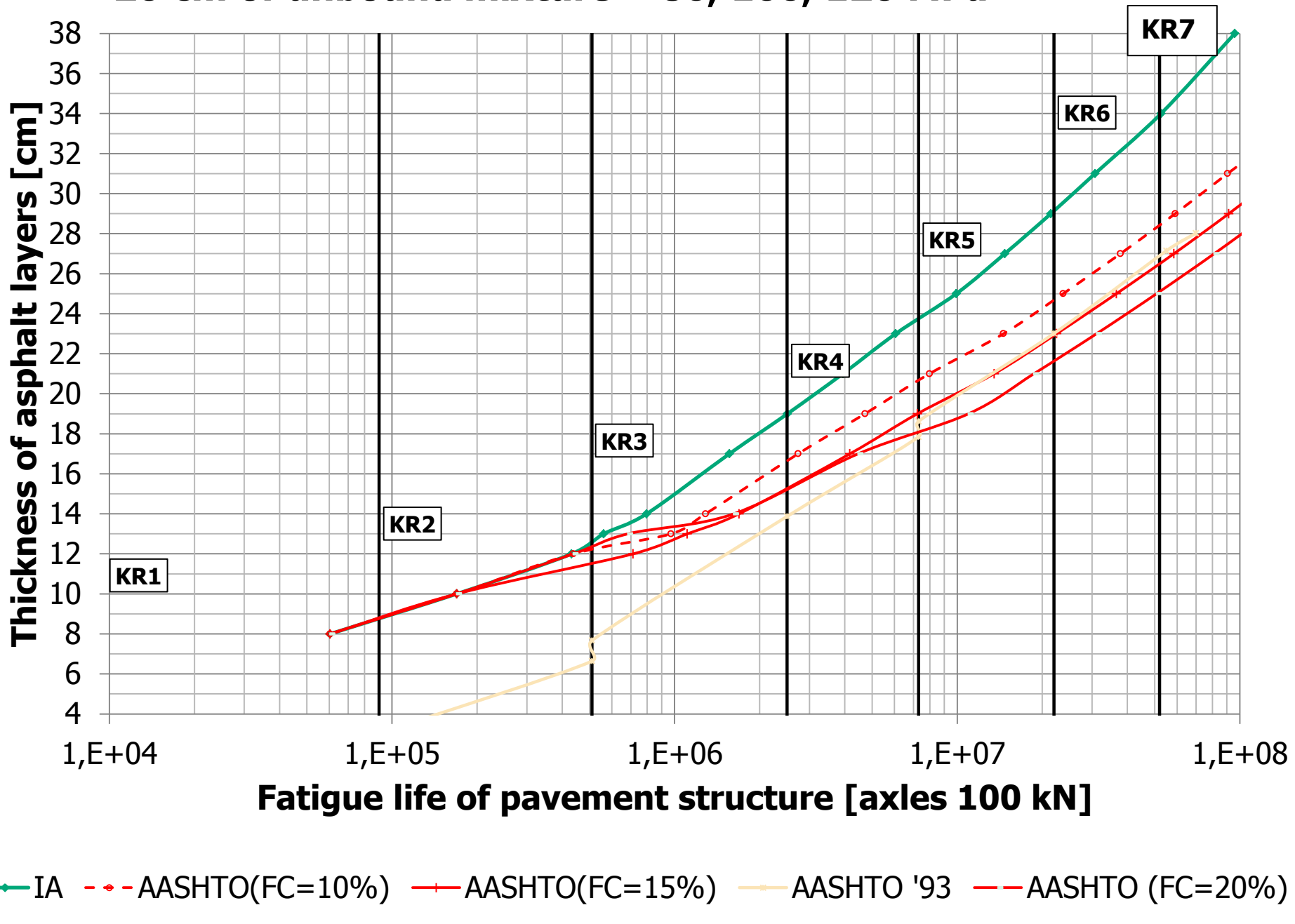
CALCULATION ASSUMPTIONS (2)

- Wheel load - 850 kPa, 50 kN (old: 650 kPa, 50 kN)
- Stiffness of asphalt layers (Shell method)
  - Bitumen: 35/50 i 50/70 (old: D50/70)
  - New volumetric proportion
  - New equivalent temperature
    - +13°C for flexible (+15°C) for semi-rigid

(old: +2, +10, +23°C)

Wearing Course-SMA	Binder Course-AC	U. base Course-AC	L. Base Course-UM	Subbase-HBM $C_{8/10}$	Subgrade
7300	10300	9800	400	3000/600	80

20 cm of unbound mixture - 80, 100, 120 MPa



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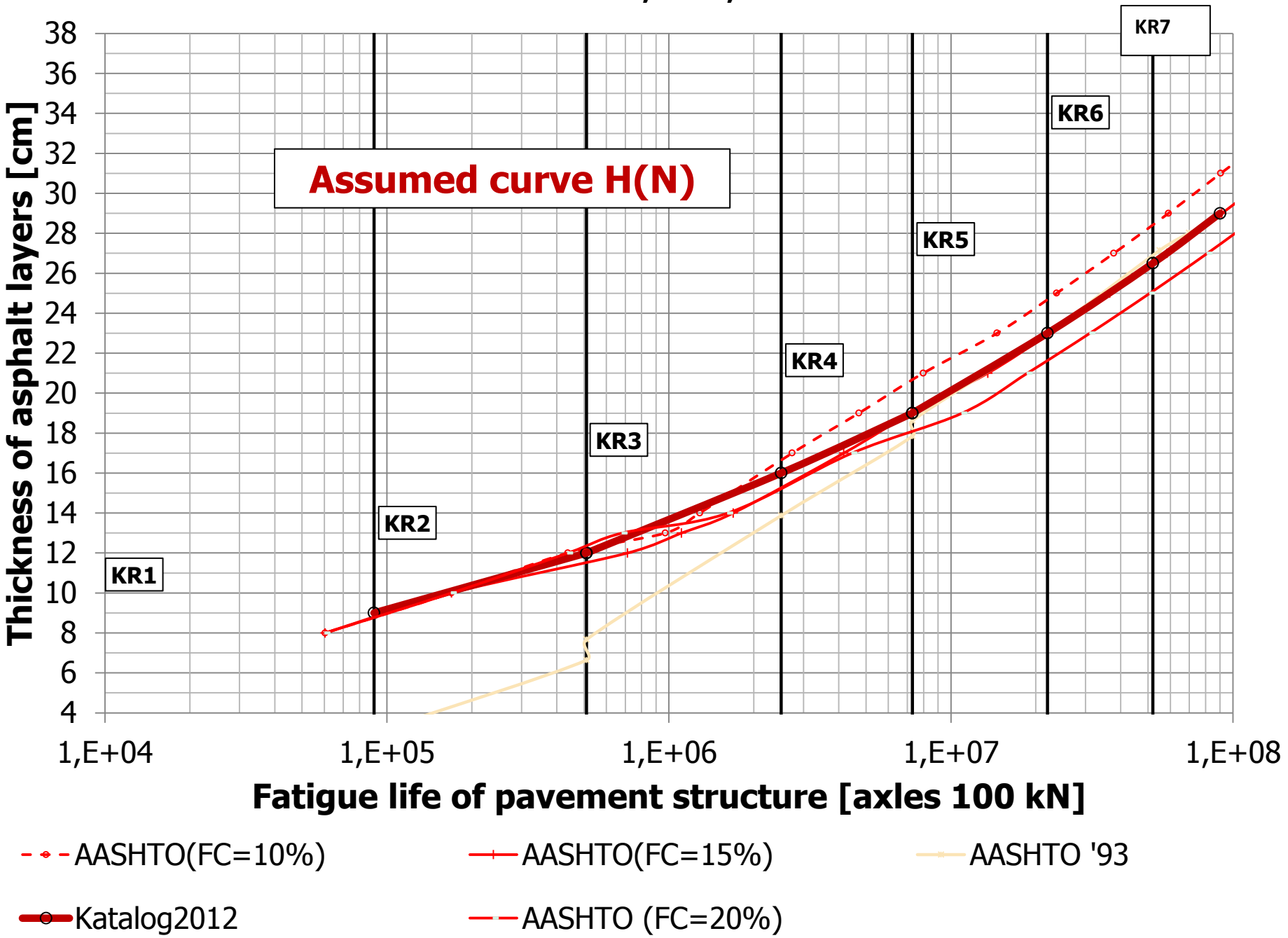

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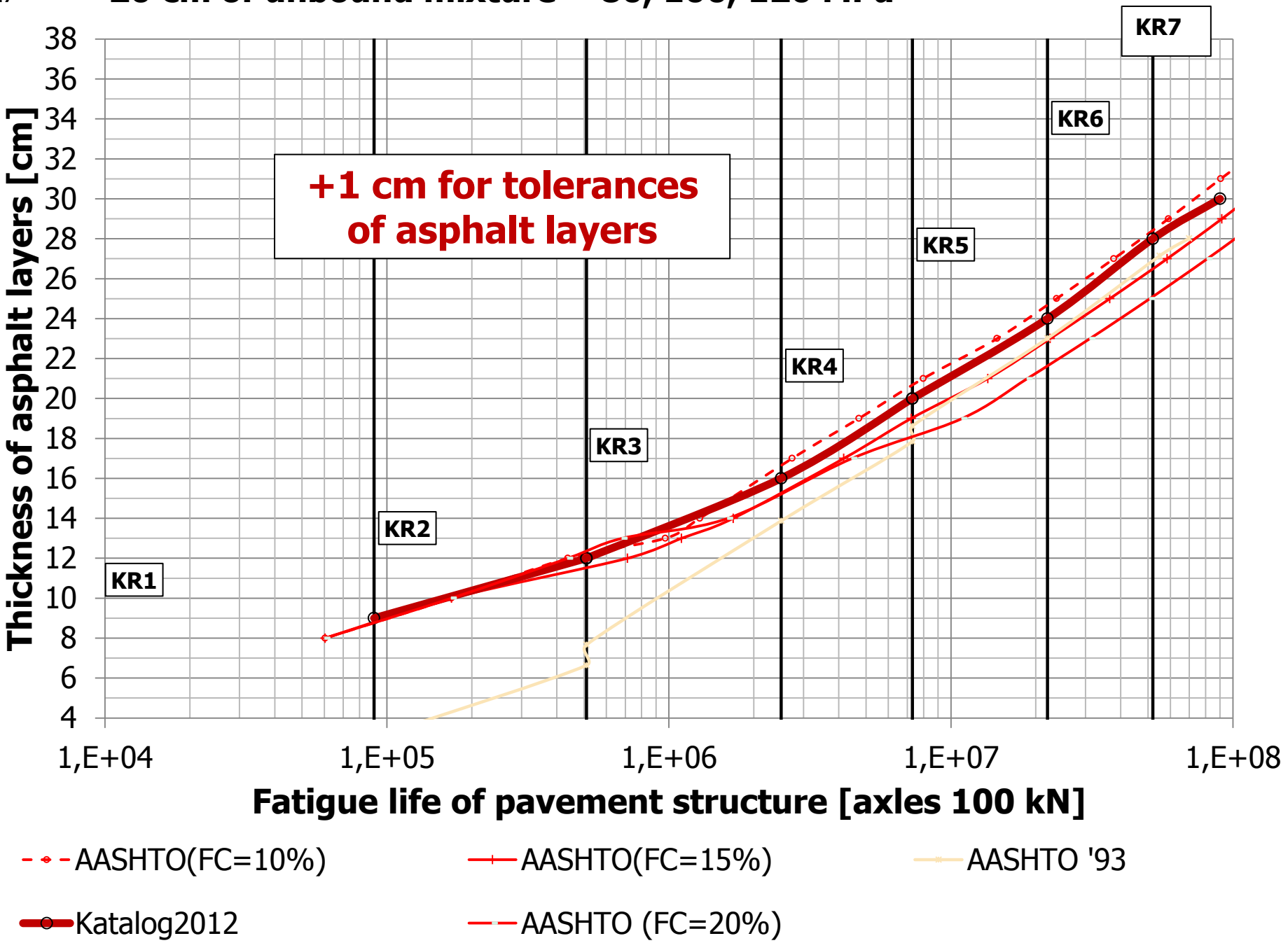

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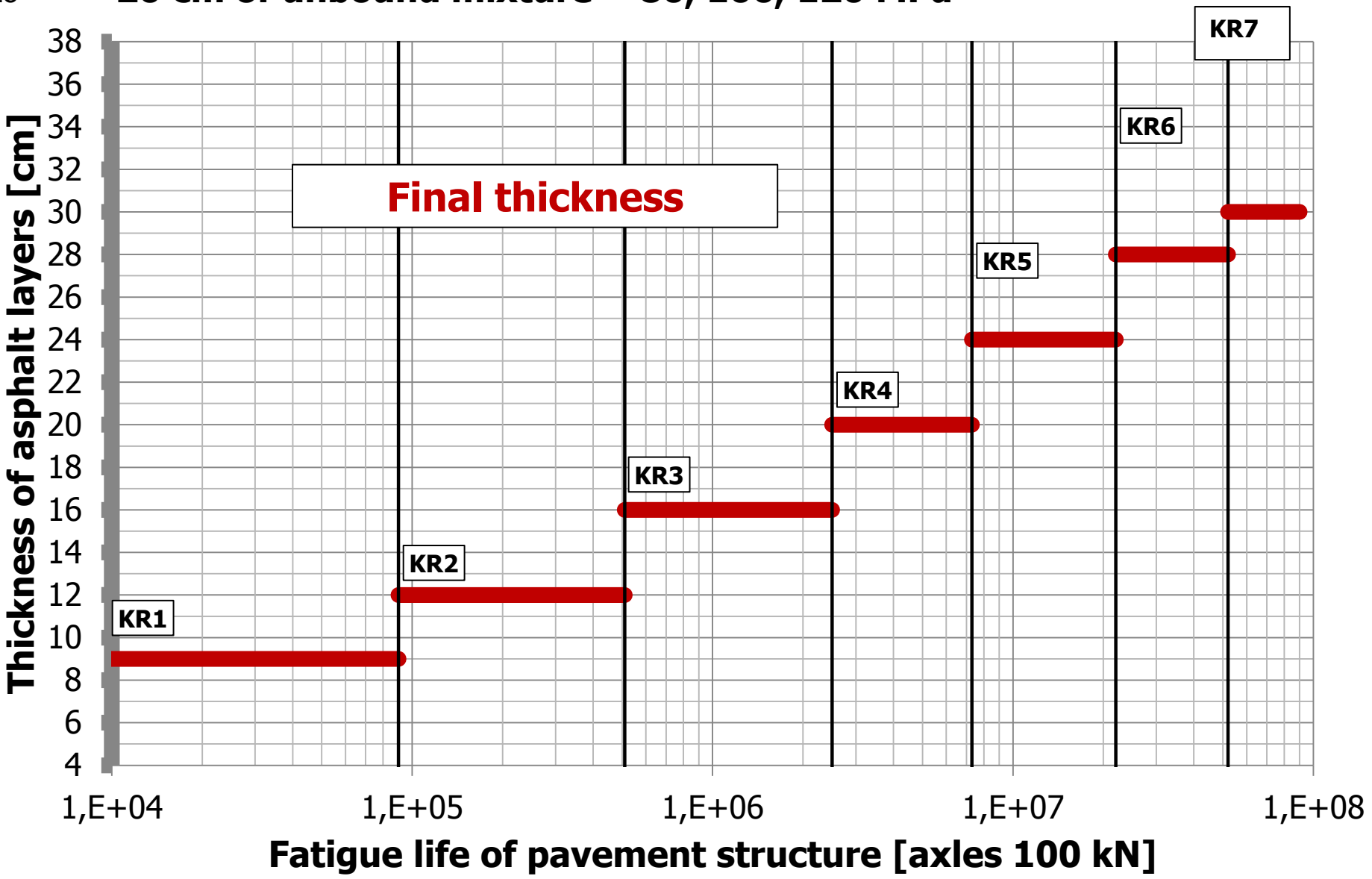
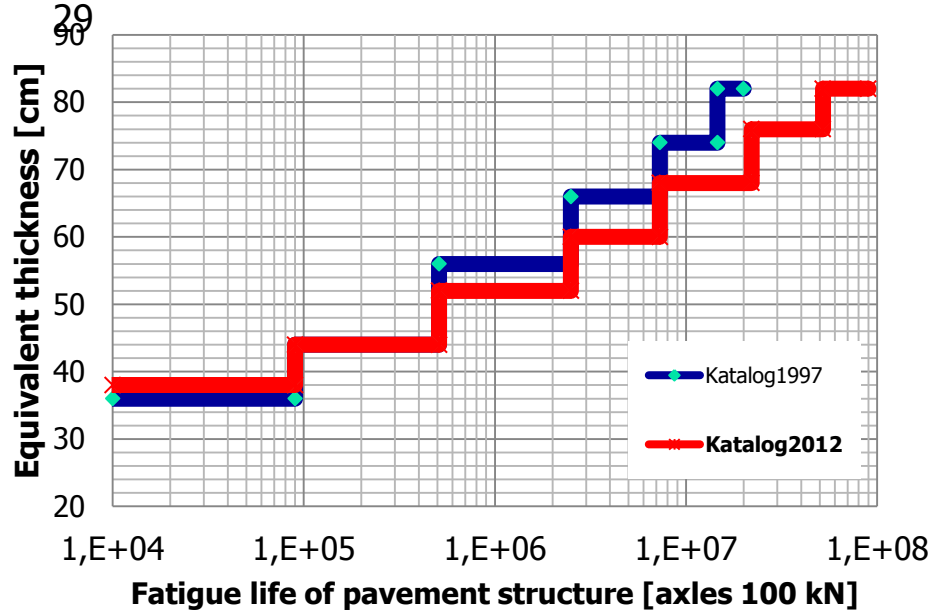
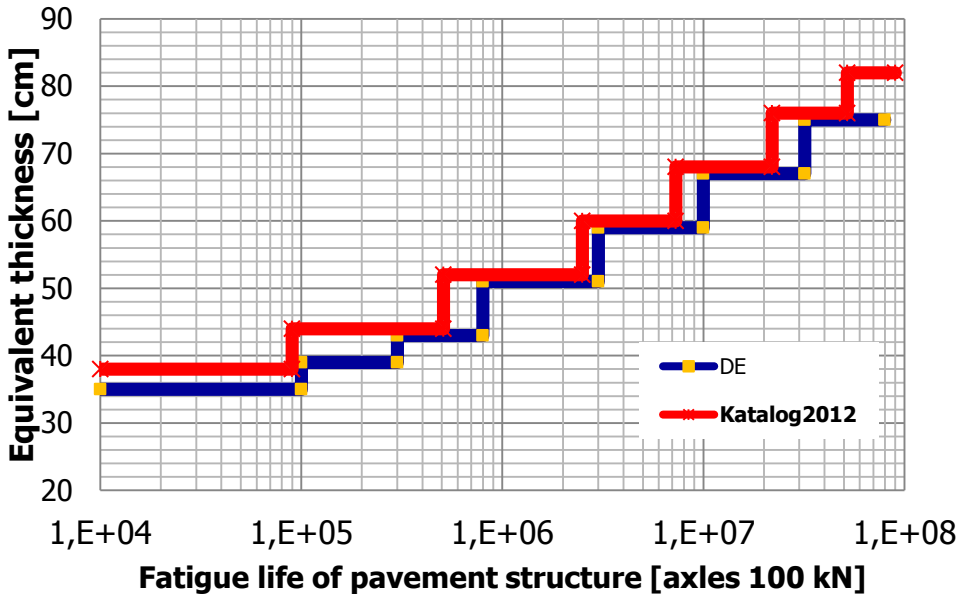
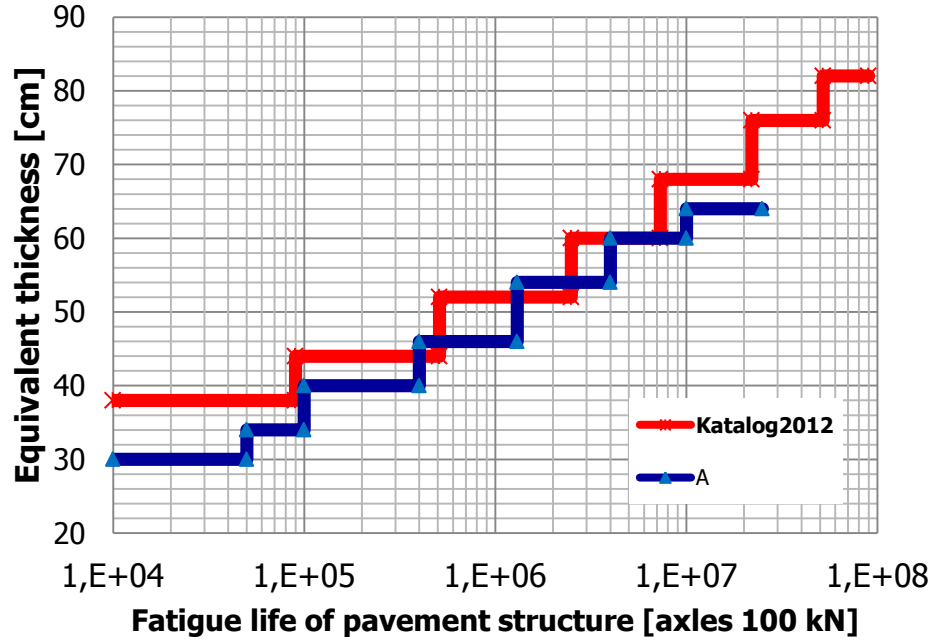
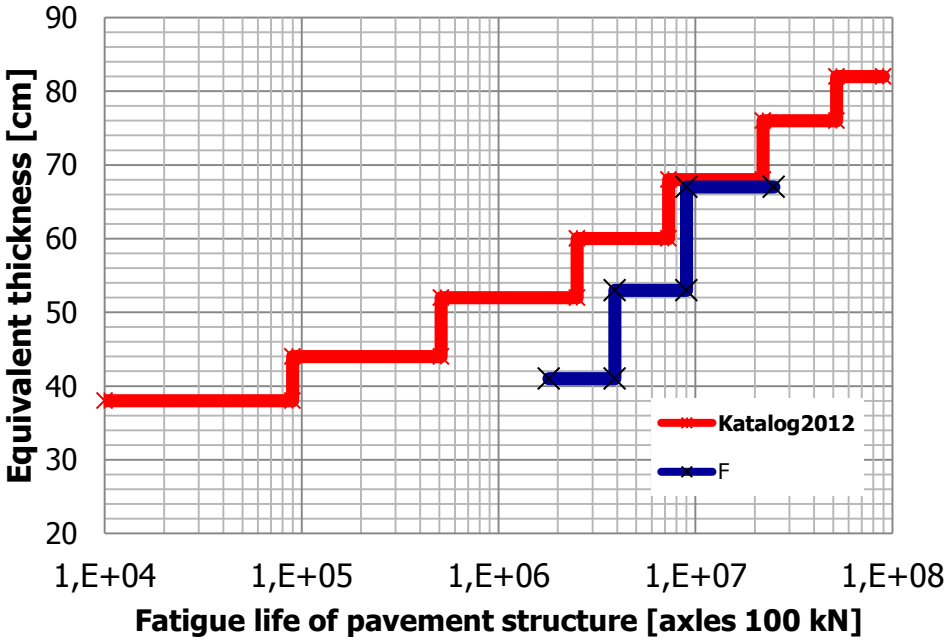


Comparison of structures (base - unbound mixture)









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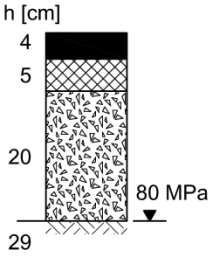
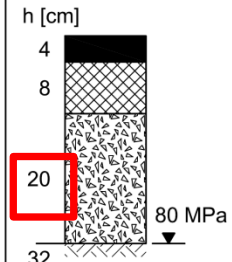
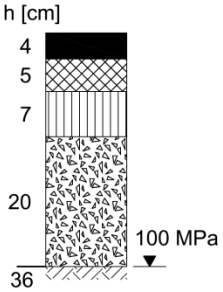
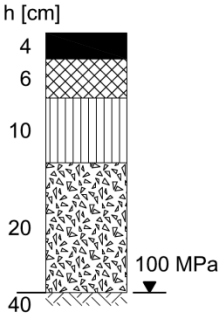
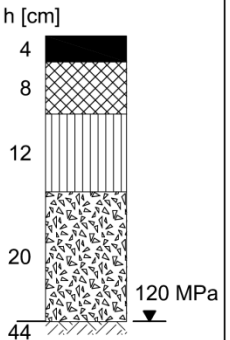
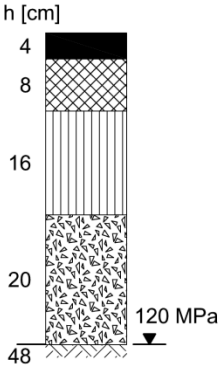
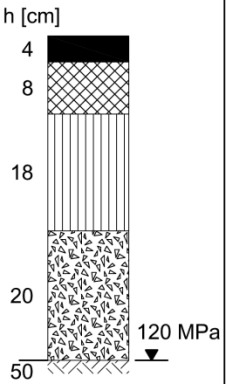
TYP A1: (upper base) - AC, (lower base) – unbound mixture $C_{90/3}$

Kategoria ruchu	KR1	KR2	KR3	KR4	KR5	KR6	KR7
Ruch projektowy (mlm osi 100 kN)	0,03 - 0,09	0,09 - 0,5	0,5 - 2,5	2,5 - 7,4	7,4 - 22,0	22,0 - 52,0	> 52,0
TYP A1							

LEGENDA:

- warstwa ścieralna z mieszanki mineralno-asfaltowej, wymagania materiałowe wg punktu 7.12
- warstwa wiążąca z betonu asfaltowego wymagania materiałowe wg punktu 7.13
- warstwa podbudowy zasadniczej z betonu asfaltowego wykonana według punktu 10.12, wymagania materiałowe wg punktów 7.14 - 7.15
- warstwa podbudowy zasadniczej z mieszanki niezwiązanej $C_{90/3}$, wykonana wg punktu 10.12, materiały wg punktów 7.14 i 7.17
- wymagany wtórny moduł odkształcenia E_2

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RESULTS – NEW STRUCTURES

Table 3. Thicknesses of the upper courses of typical pavement structures given in [11]

No.	Type of pavement	Thickness of the upper courses of pavement, cm							
		Pavement course	Traffic class						
			KR1	KR2	KR3	KR4	KR5	KR6	KR7
1.	Flexible	Asphalt layers	9	12	16	20	24	28	30
		Unbound base, $C_{90/3}$	20	20	20	20	20	20	20
2.	Flexible	Asphalt layers	9	12	16	20	24	28	30
		Unbound base, $C_{50/30}$	22	22	22	22	22	22	22
3.	Flexible	Asphalt layers	9	12	-	-	-	-	-
		Unbound base, C_{NR}	25	25	-	-	-	-	-
4.	Flexible	Asphalt layers and base	14	18	22	26	30	34	36
5.	Flexible	Asphalt layers	8	12	12	16	-	-	-
		Mineral/cement/emulsion/ FBit base	15	15	20	20	-	-	-
6.	Semi-rigid	Asphalt layers	9	11	15	18	20	22	24
		Hydraulically-bound base	18	20	20	22	22	24	24
7.	Semi-rigid	Asphalt layers	9	11	-	-	-	-	-
		Hydraulically treated soil base	18	20	-	-	-	-	-

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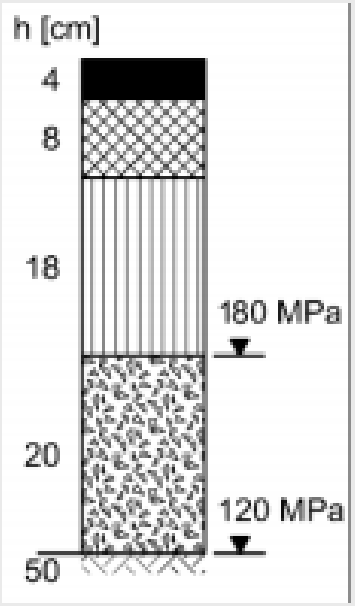
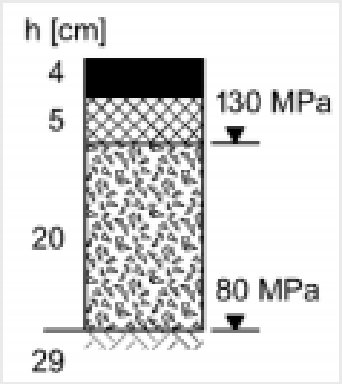
STRUCTURE EXAMPLES

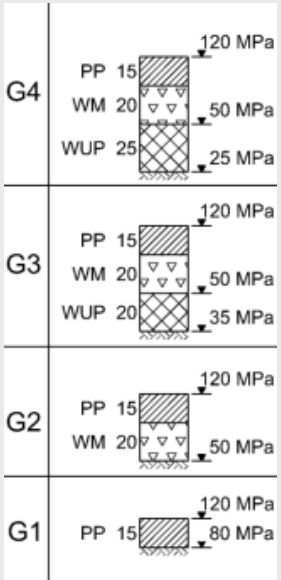
KR7 – 52-90 mln 100 kN KR1- 0,03-0,09 mln 100 kN

Upper layers -





Lower layers and improved subgrade -

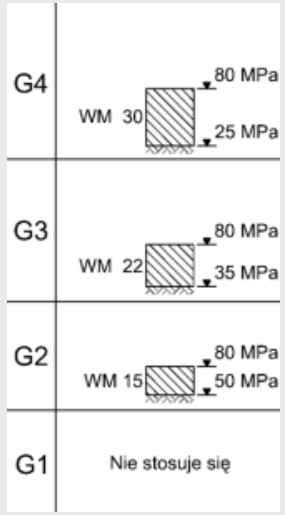


Very weak subgrade
(E2>25 MPa or 2<CBR<3%)

Weak subgrade
(E2>35 MPa or 3<CBR<5%)

Quite good subgrade
(E2>50 MPa or 5<CBR<10%)

Strong subgrade
(E2>80 MPa or CBR>10%)



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Catalogue