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DEPARTMENT OF TRANSPORTATION ENGINEERING

INFLUENCE OF NEW VEHICLE TYPES ON ROAD PAVEMENT DESIGN IN CROATIA

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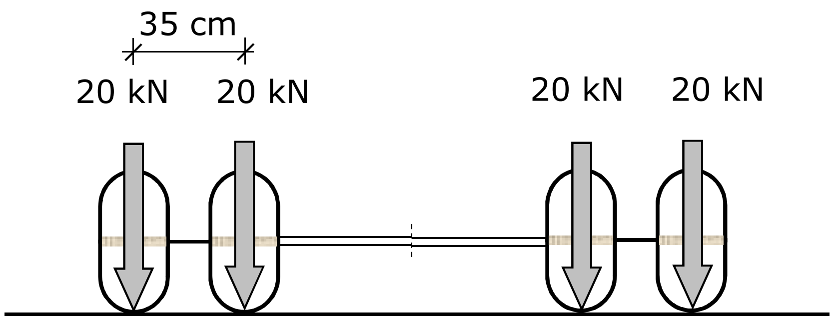
Introduction

- **flexible pavement design** is performed according to standard HRN.U.C4.012
  - dates from 1981
  - standard is based on the AASTHO Guide method
  - traffic load expressed in passages of ESAL of 80 kN
  - method is adjusted for usage in Croatia

Introduction

- **traffic load** is calculated according to HRN.U.C4.010
  - dates from 1981
  - standard is based on the AASTHO Guide method
  - uses “Fourth power law” for LEF
  - ESAL: single axle, double tyres, 80 kN

$$LEF = \left(\frac{L_x}{L_N}\right)^4$$



Introduction

- problems in pavement design:
  - today's vehicles have different weight and axle load than those described in standard,
  - today's vehicles have greater axle load – LEF is calculated with smaller load (according to standard)
  - Ordinance* based on EC Directive 96/53 allows 100 kN
  - HRN Standard prescribes 80 kN – design method

* Ordinance on Technical Conditions of Vehicles in Traffic on Roads

Pavement design in Croatia

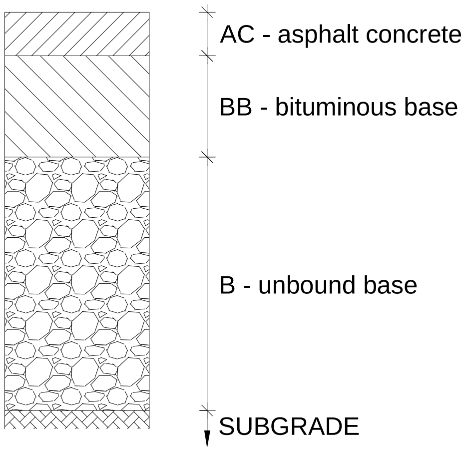
HRN U.C4.012

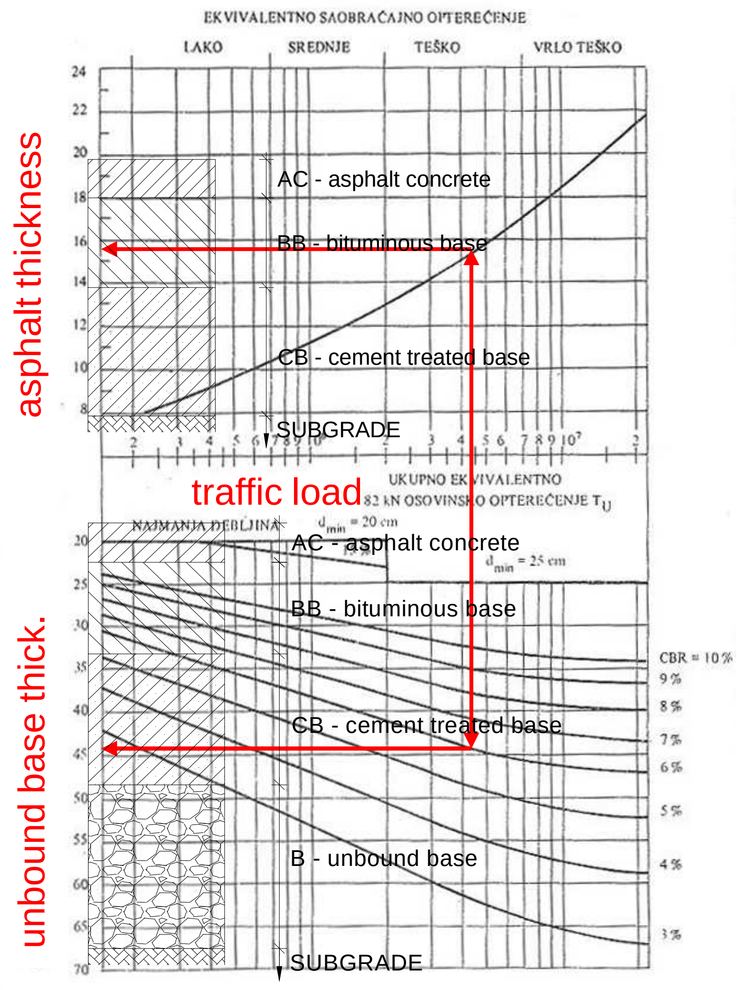
- based on AASHTO method with some simplifications:
  - terminal serviceability index: $p_t=2,5$
  - regional factor: R=2,0
- layer thickness is determined directly
- design period is 20 years
- three types of pavements...

Pavement design in Croatia

HRN U.C4.012 ... (continued)

- types of pavements





Determination of traffic load

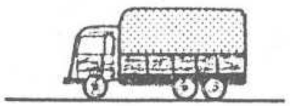
HRN U.C4.010

- vehicles with axle load >20 kN
- design period 20 years (traffic growth included)
- average usage (loading) level – 70%
- distribution in traffic lanes
- eight groups of representative vehicles

Determination of traffic load

HRN U.C4.010 (continued)

- Example of "**heavy vehicle, TT3**" from standard

Heavy vehicle, TT3						
Number of axles: 3						
Carrying capacity: >70 kN (145 kN)						
	load disposition					
	front axle		**rear axle**		**total**	
	[kN]	**[%]**	**[kN]**	**[%]**	**[kN]**	**[%]**
empty vehicle weight	**37**	**50**	**37**	**50**	**74**	**100**
useful load	**25**	**17**	**120**	**83**	**145**	**100**
total weight of full vehicle	**60**	**27**	**2×80**	**73**	**220**	**100**

Determination of traffic load

HRN U.C4.010 (continued)

- calculation of LEFs
  - single axle: **LEF** = $2{,}212 \times 10^{-8} \times L_1^4$
  - double axle: **LEF** = $1{,}975 \times 10^{-9} \times L_2^4$
- equivalency factor for vehicle: **Σ LEF**
- <u>Σ LEF</u> × <u>AADT</u> × <u>growth rate</u> = **traffic load**

Determination of traffic load

HRN U.C4.010 (continued)

PROBLEMS:

- axle load of new vehicles is greater than for vehicles in standard
- different data from different counting points
- no equation for triple axle

Pavement design

Different traffic loads

According to HRN U.C4.010 for counting point 3106-Slunj:

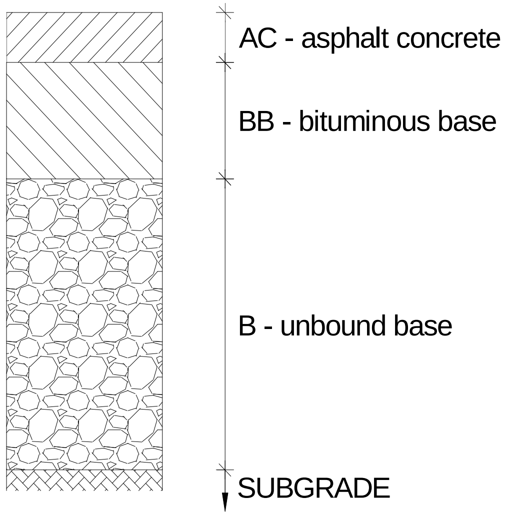
- $N_{ESAL\ 80\ old}$ = **5,51×10⁶** of $ESAL_{80}$ (80 kN,old vehicles)

- $N_{ESAL\ 80\ new}$ = **34,63×10⁶** of $ESAL_{80}$ (80 kN,new veh.)

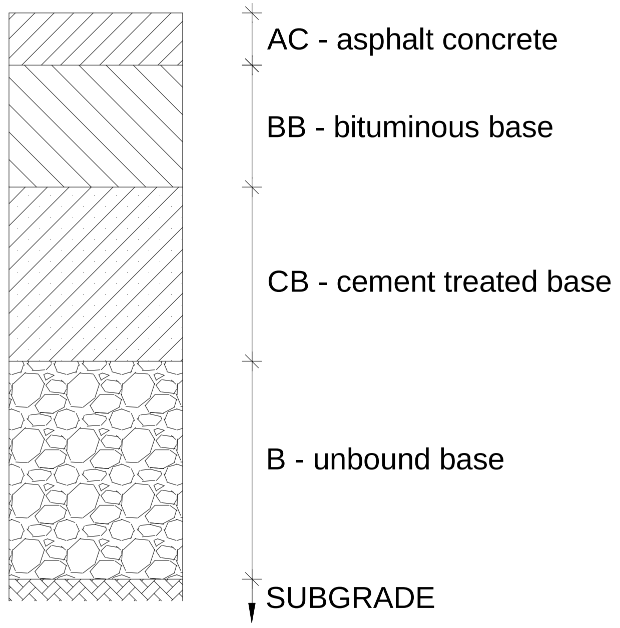
Pavement design

Different pavement types

type 1



type 2



Pavement design

Dimensions

pavement type	layers	dimensions [cm]	
		a $5{,}51 \times 10^6$	b $34{,}63 \times 10^6$
type 1	asphalt concrete (AC)	6	6
	bituminous base (BB)	10	19
	unbound base (B)	35	35
type 2	asphalt concrete (AC)	6	6
	bituminous base (BB)	8	15
	cement treated base (CB)	20	20
	unbound base (B)	25	25

a – designed for traffic load $N_{ESAL80old}$

b – designed for traffic load $N_{ESAL80new}$

Calculations

- Stresses & strains: **BISAR 3.0**

  - **critical positions for asphalt & cement treated layers:** bottom of layers beneath wheels

  - **critical position for subgrade:** top of the layer between wheels

Calculations

- Fatigue for asphalt layers: **BANDS 2.0**
- Fatigue for cement treated layer: **PCA eq.**

$$N_{fatigue} = \left(\frac{4.2577}{\frac{\sigma}{S_C} - 0.4325} \right)^{3,268}$$

- Fatigue for subgrade:

Shell Pavement Design Manual

$$\varepsilon_c = 2.8 \cdot 10^{-2} \cdot N_{fatigue}^{-0,25}$$

Results

- distribution of traffic on seasons (summer, winter, spring/autumn)
- Miner's rule was applied:

$$\sum \frac{n_i}{N_i} \leq 1$$

n_i – no. repetitions at strain σ

N_i – no. of repetitions at fatigue

Results

pavement type	layers	dimensions [cm]		
		a 5,51×10^6	**b** 34,63×10^6	**b** 34,63×10^6
type 1	bituminous base (BB)	10 ✓	10 ✗	19 ✓
	unbound base (B)	35 ✓	35 ✓	35 ✓
type 2	bituminous base (BB)	8 ✓	8 ✓	15 ✓
	cement treated base (CB)	20 ✓	20 ✗	20 ✓
	unbound base (B)	25 ✓	25 ✓	25 ✓

a – designed for traffic load $N_{ESAL80old}$
b – designed for traffic load $N_{ESAL80new}$

Conclusions

- legally prescribed max. axle load: **100 kN**
  design axle loads: **80 kN**
- Croatian design method gives cca 25% greater asphalt thickness than necessary
- such thickness is insufficient for nowday's traffic
- **pavement design** & **traffic load method** should be optimised for characteristics of present-day vehicle types, due to tendency of increasing axle loads

THANK YOU!