Asphalt Pavements and the Environment

some News from the Netherlands

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Some Statistics

2500 km main highway system

100.000 vehicles/day
15 % trucks
3.5 axles of 100 kN/truck
9 % overloaded

time slot for maintenance 21 pm – 5 am

2 % < CBR < 5 % in western part of the country

16 million inhabitants

≈1.6 x Massachusetts and 0.5 x Maine

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Design, Build, Finance and Maintain Contracts

- Large projects
- Duration contract 30 years
- Within certain boundaries has maximum freedom in selecting materials and structures
- Durability is introduced as one of the decision factors

Preferences to be taken into account in A12 LuVe project

virtual amount of money is added to initial bid if preferences are not or only partly fulfilled

- **Optimum collaboration with client and information to public 15 million €**
- **Hinder to traffic during construction 50 million €**
- **Hinder to traffic during exploitation 20 million €**
- **Hinder to traffic on the secondary road system 15 million €**
- **Durable solution (minimize environmental hinder) 15 million €**

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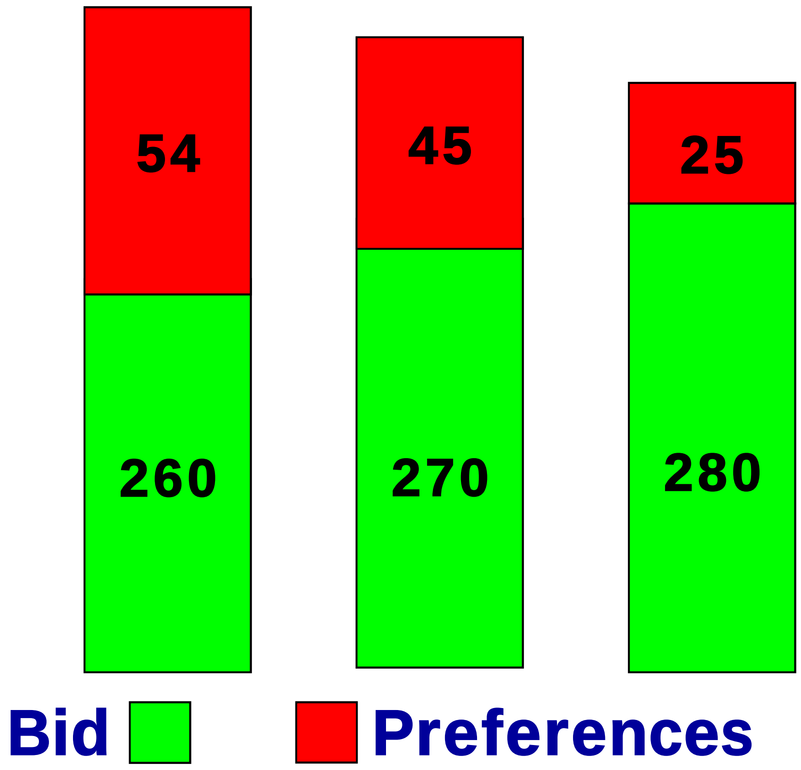
Conclusion

- **Durability plays a role but Availability plays a much more important role**
- **Theoretically it is possible that an environmentally unfriendly solution is accepted because it maximizes availability**
- **However, the use of environmentally unfriendly products like tar-containing products is banned**

Total Price

- Total price = bid + preferences
- Ceiling = € 350 million
- If total price > ceiling then bid is invalid

Outcome of the Bidding for the A12 LuVe project



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Contractual Risks

Penalties one has to pay when working outside agreed time frame

Phase	Day	Time frame ($AV_{1/4h}$)			
Construction phase		00.00-05.00	05.00-08.00	08.00-22.00	22.00-00.00
Construction phase [redacted]	[redacted]	[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]		[redacted]	

≈ $ 32,500

How is Sustainable Contracting promoted in the Netherlands?

Purchasing Sustainability

- **Durability in Contracts**
  - **Sustainability Profile of a Company (30%)**
    - **Sustainability Profile (70%)**
    - **Measures (30%)**
  - **Sustainable Design (70%)**
    - **DuBo-Calc Environment Score (70%)**
    - **Measures (30%)**

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Sustainability Profile of a Company

- What is the company's policy with respect to
  - energy use
  - energy reduction
  - communication
  - CO_2 reduction policies
  - CO_2 management in the company
- Company should not only look to itself but also to suppliers etc

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DuboCalc

- Software tool to determine environmental effects of usage of materials and energy for building structures
- 10 environmentally important aspects are evaluated by means of one single indicator being the Environment Cost Indicator

Aspects considered

• Acidification (SO_2 equivalent)	€ 4 / kg
• Damage to Ozone layer (CFK-11 eq)	€ 30 / kg
• Climate change (CO_2 eq)	€ 0.05 / kg
• Eco-toxicity (1.4-DCB eq dichlorobenzene)	€ 0.06 / kg
• Smog (C_2H_2 eq)	€ 2 / kg

How Calculated

- Data base of products and materials for which environmental load is determined
- Based on type and quantities of materials used ECI is calculated
- ECI is used as fictitious increase of bid

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Disadvantage

- You have a hard time to get your product accepted by the market if it is not in the data base

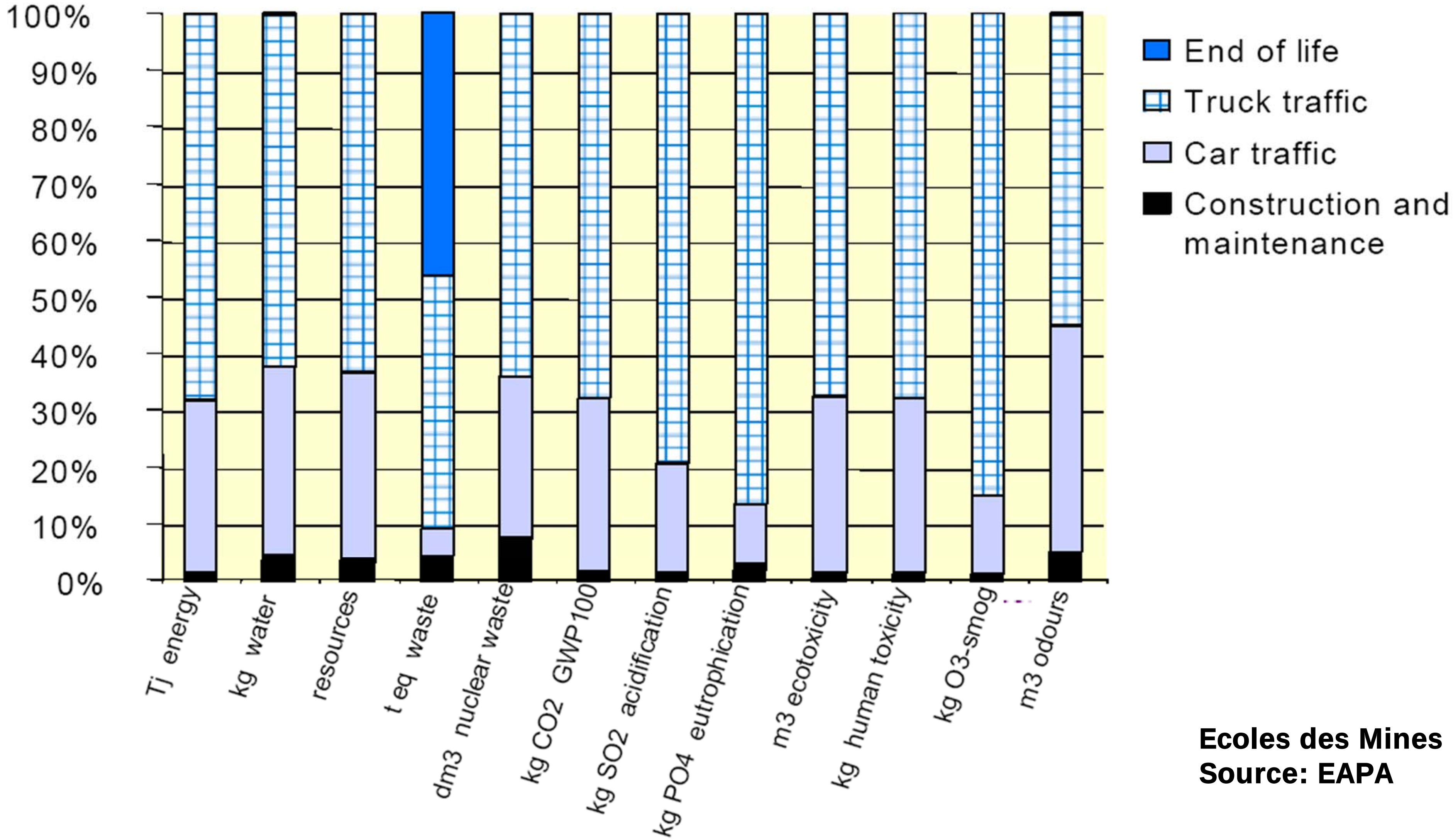
DuboCalc

- For Ministry of Transport contracts
- Provincial and City authorities (85% of the market) are still struggling with the concept
- Price is in most cases decisive factor
- Only a few DBFM contracts
- Many DB contracts
- Many have extended warranty period (5 – 7 years)

Preserving the Environment is a Necessity

- Reduce energy consumption
- Reduce global warming (reduce CO_2 production)
- Reduce acidity levels
- Reduce use of virgin materials
- Promote recycling
- Reduce fine dust levels
- Reduce noise levels
- Etc etc

Traffic itself is the biggest Polluter



Ecoles des Mines
Source: EAPA

Conclusion

- The biggest contribution of the road industry to limit pollution is by providing structures which will result in less pollution by traffic
- This implies:

  - long life pavements

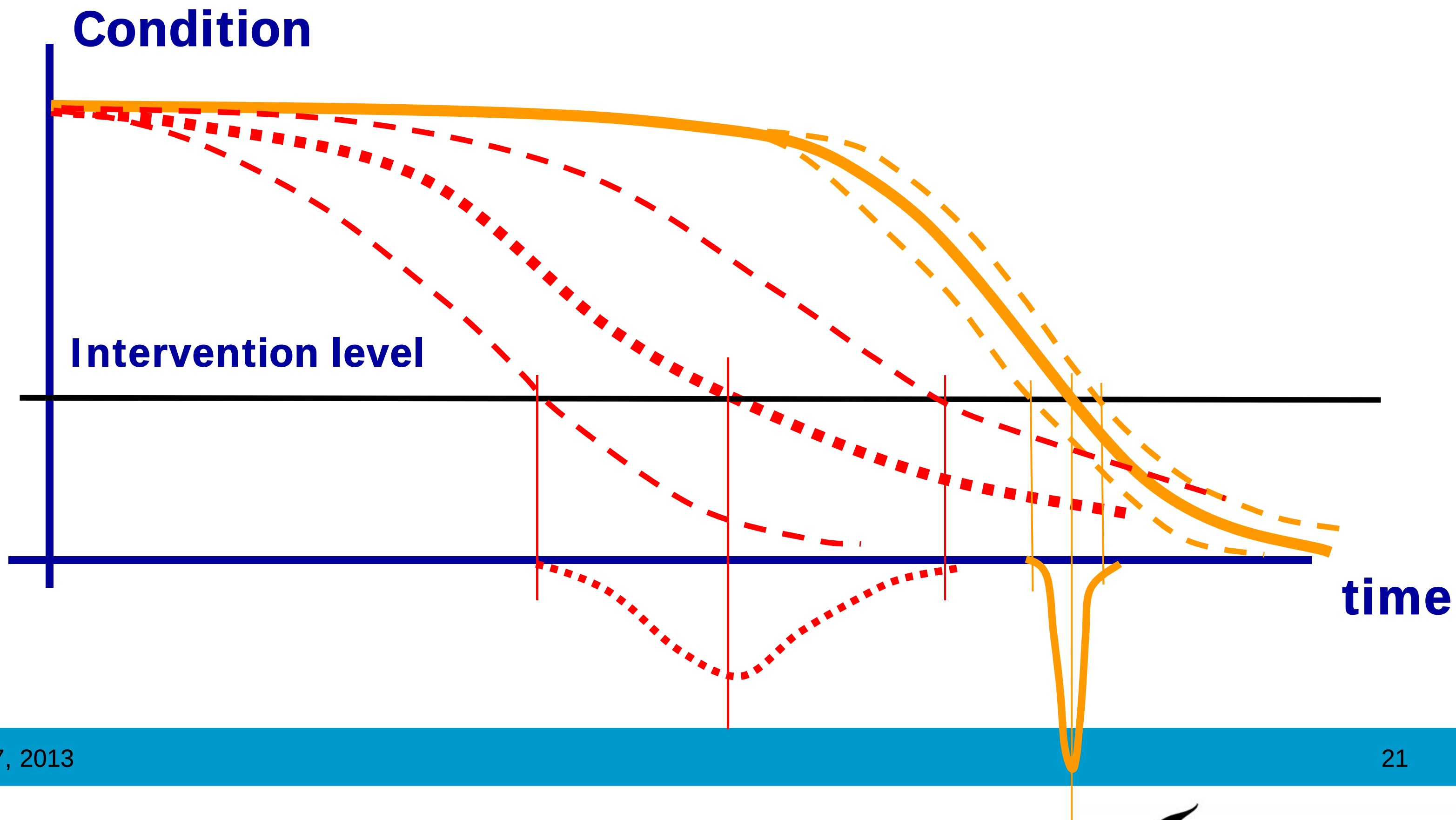
  - low rolling resistance

  - low noise production

  - etc

Durable (long life) of pavements are a prerequisite for sustainable pavements

Longer average Lifetime and less Variation in Properties will reduce Traffic Hinder, Costs and Pollution



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Better Quality will give Better Performance and will Reduce Polution

- **We build our pavements with too much variability**
- **This results in:**

  - premature failure

  - too early maintenance

  - need for higher maintenance budgets

  - more delays due to maintenance and rehab

  - and therefore more fumes, CO_2, energy consumption etc

Effect of reduced Variability of Porous Asphalt Concrete on Costs and Delay Hours

	10 % of sections has failed after [years]	50 % of sections has failed after [years]	90 % of sections has failed after [years]	Mainte-nance costs	Delay hours
Currently	7	11	16	1	1
In case of reduced variability	9	13	16	0.8	0.9

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Reduction of Variation starts already with proper Storage of Aggregates

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RAP Sorting

Sorting RAP is very important to obtain good quality recycled mixtures!

← **8 – 20 mm**

Courtesy: Rasenberg Contractors

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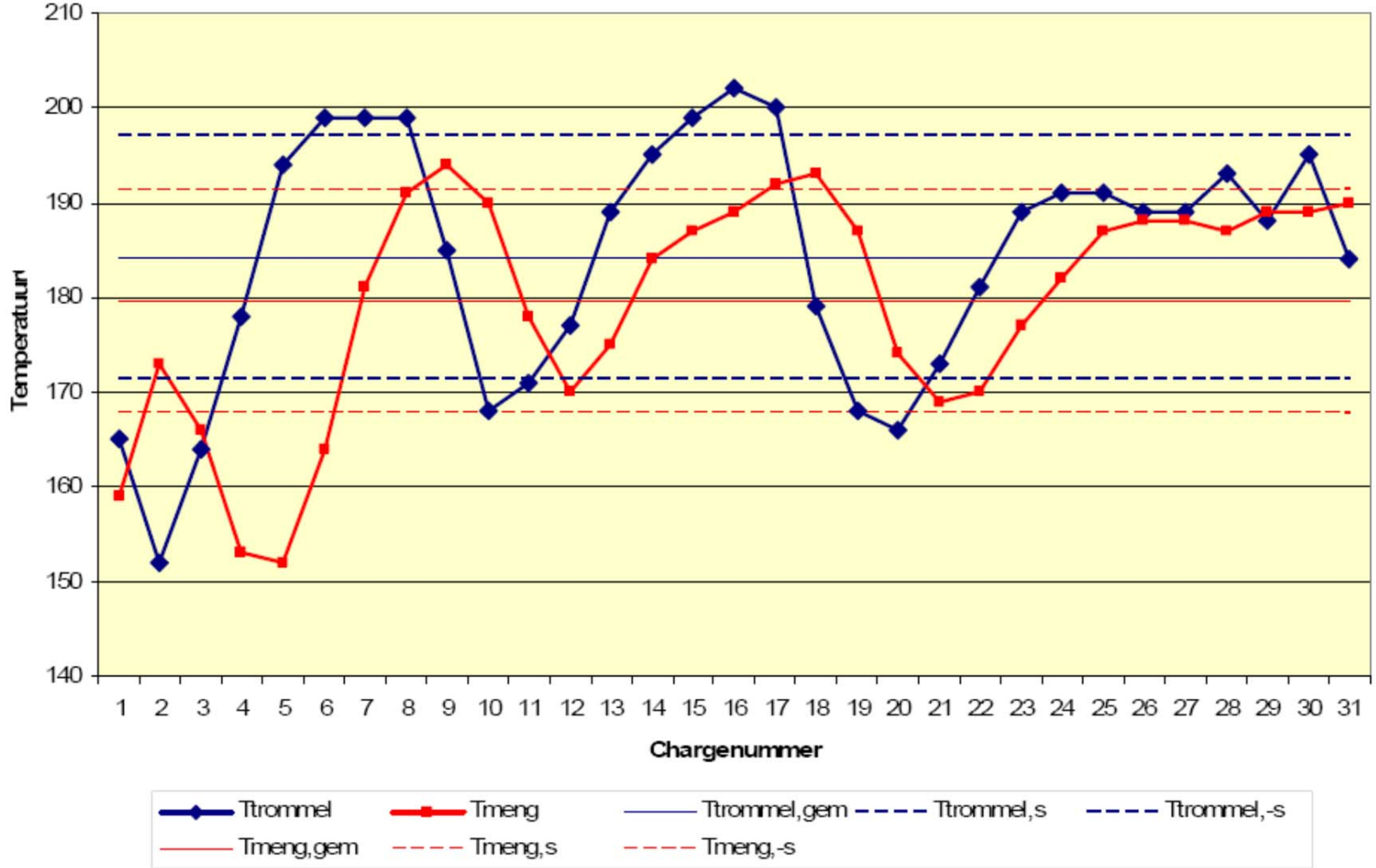
Temperature variation during production



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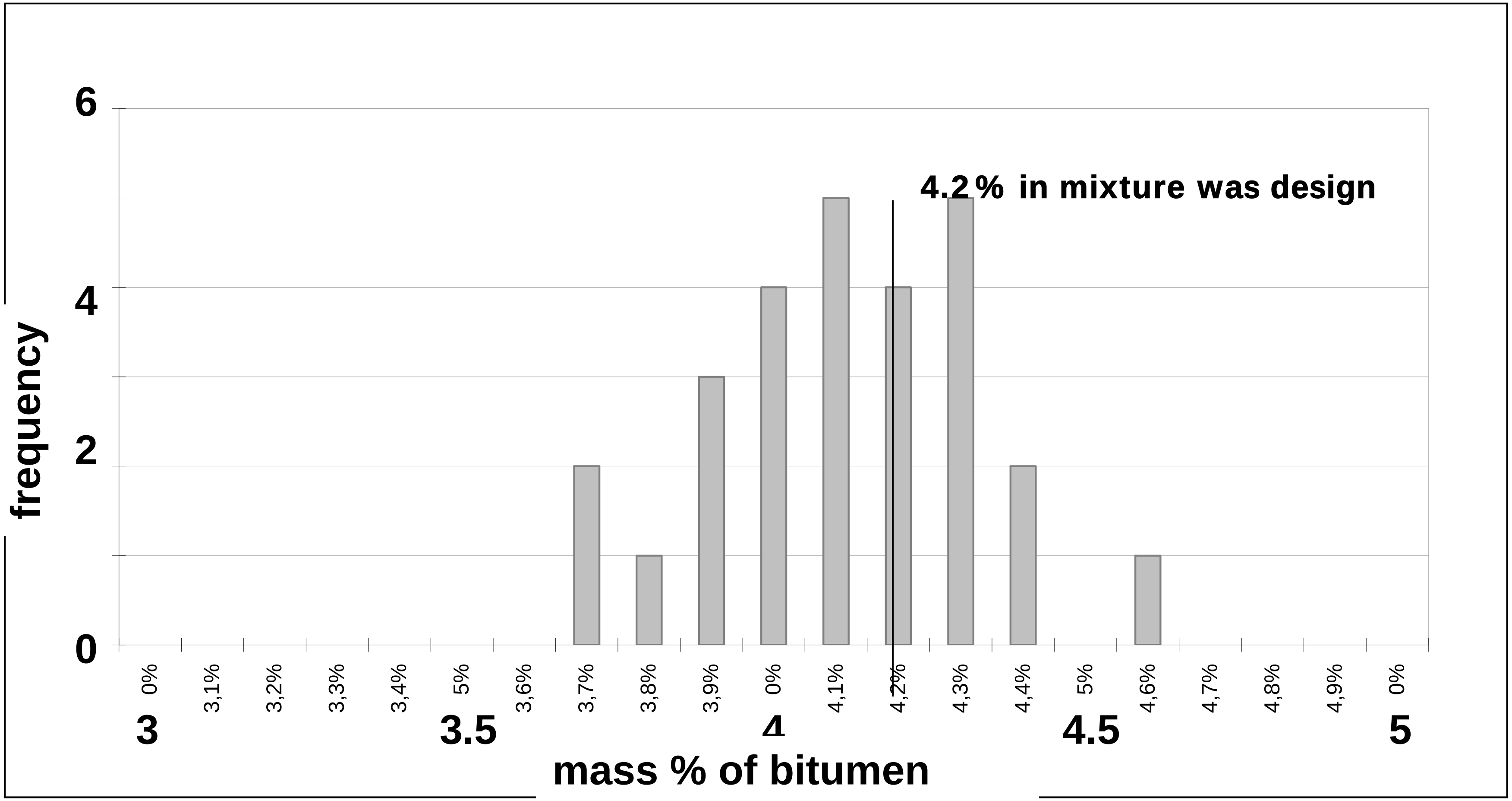
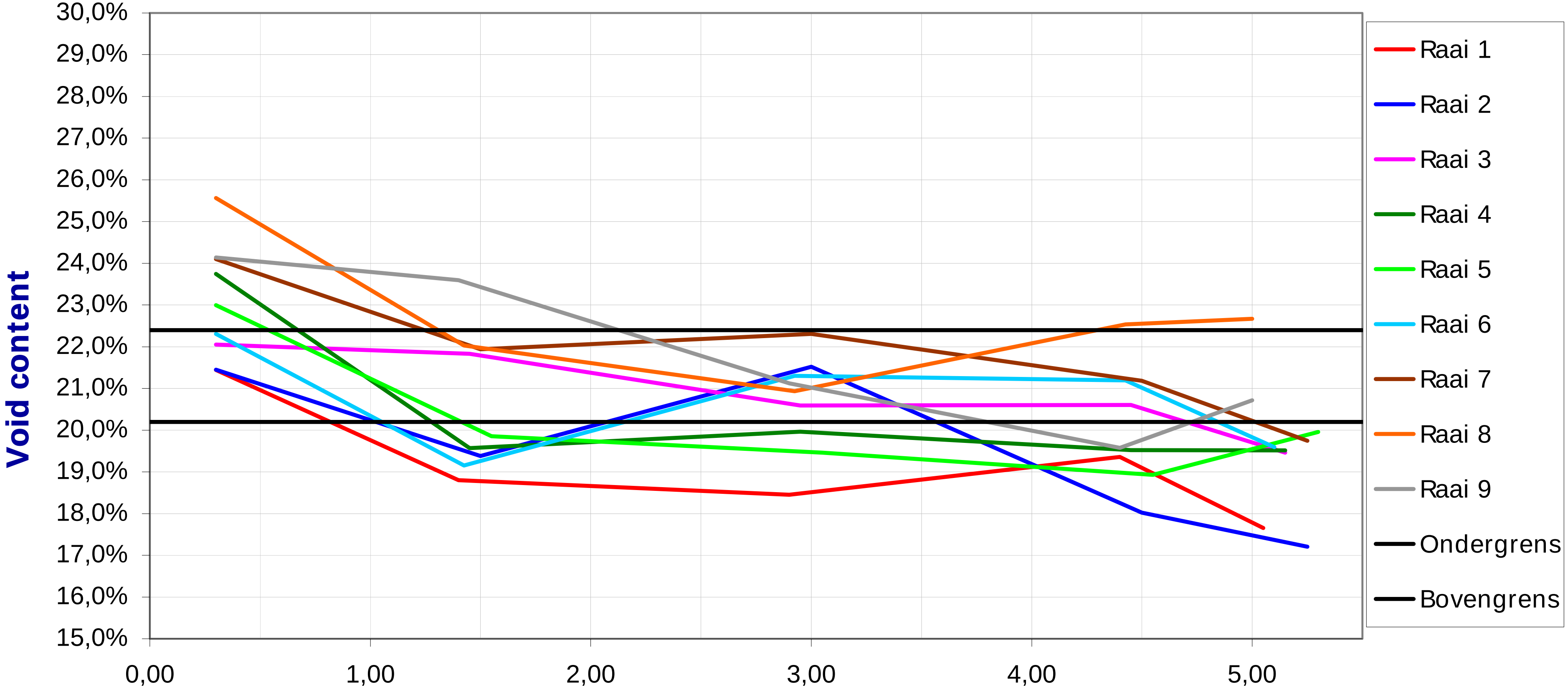
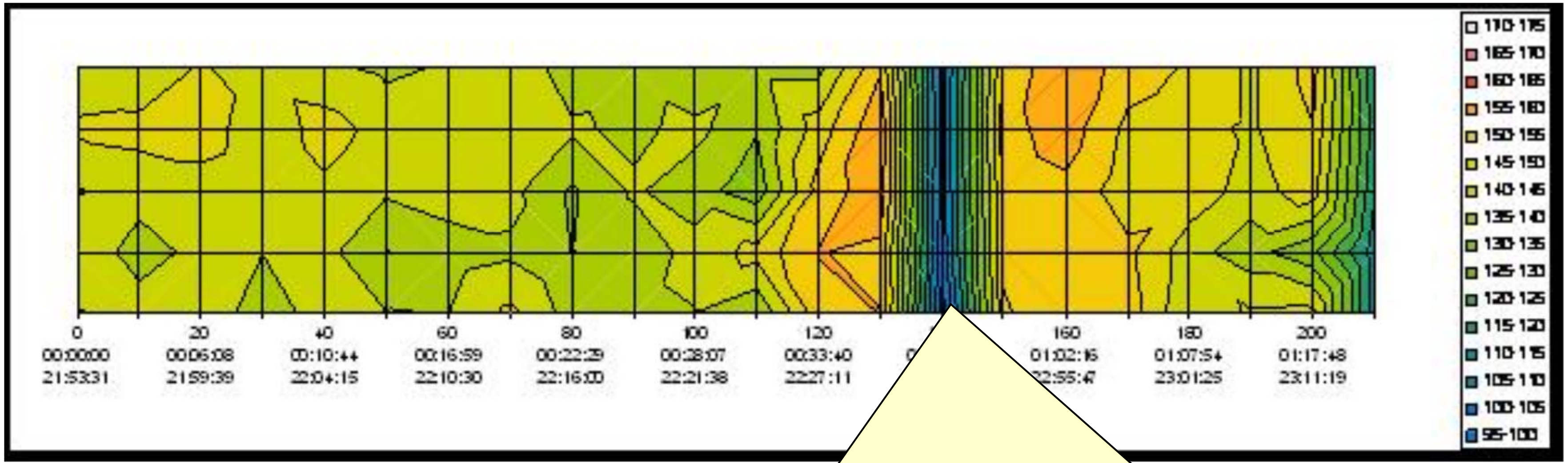
Frequency distribution Bitumen Content PAC



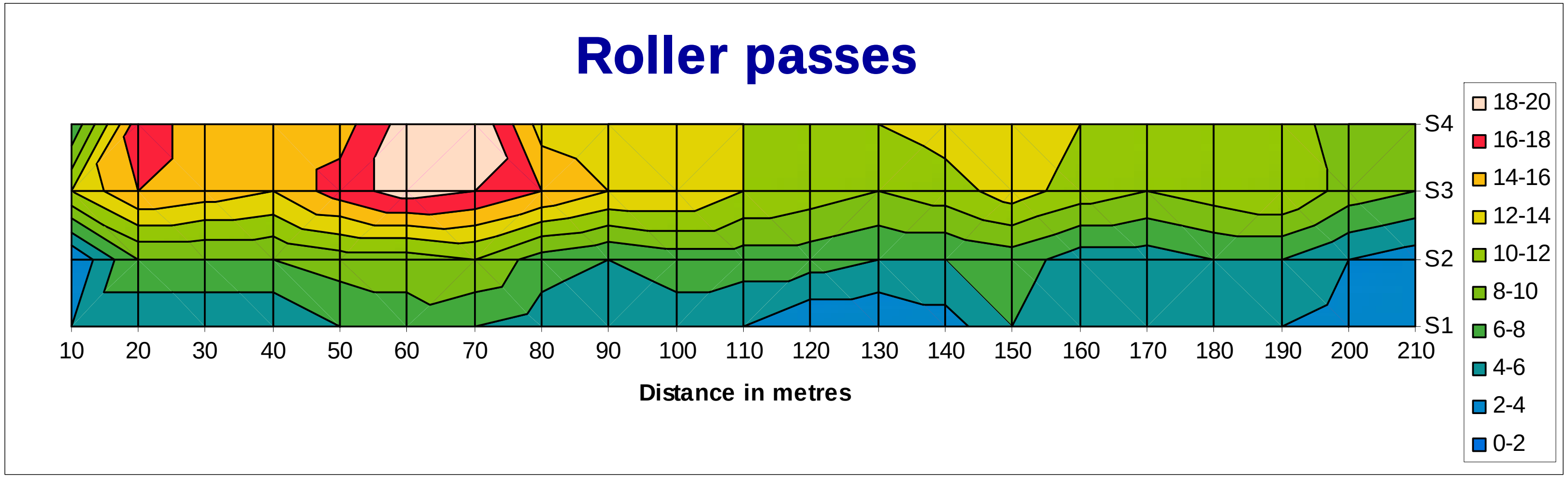
Variation Void Content Porous Asphalt Concrete



Location at transverse profile width (o = edge of pavement)



Cooling of the asphalt when the paver stopped



Source: S.R. Miller, Twente University

Conclusion

- **We must do a better job in producing and laying mixtures ! High and homogeneous quality is required !**
- **Important factors to control are a.o.:**
  - **- workmanship**
  - **- segregation**
  - **- temperature**
  - **- compaction**

- **We must further improve existing equipment.**
- **Computer controlled systems are a must (e.g. intelligent compaction)**

So I asked the Dutch Asphalt Paving Contractors

- **“Given these major changes in contracting, I guess your top three priorities in running your business are:**

  - production - quality - durability”
- **Their answer was:**

  “André you got it completely wrong, our top 10 priorities are:”

Top 10 priorities for Dutch Asphalt Paving Contractors

1. Production
2. Production
3. Production
4. Production
5. Production
6. Production
7. Production
8. Production
9. Production
10. Production

Reality

- Big bonus is paid if work is completed earlier than agreed
- High penalty has to be paid if work is completed later than agreed

Conclusion

- **Most contracts are driven by “short term availability thinking” and durability only seems to be (at best) a secondary issue**
- **“Durability” must start when setting up a contract. This is the clients responsibility!**

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Surfaces with low rolling condition contribute significantly to reduction CO_2 and NO_x emissions

- Until now confusing and conflicting information on this issue
- More in depth studies are required
- Holistic approach absolutely needed
  - fuel consumption - noise reduction
  - skid resistance - durability
  - sustainability

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Road Surface and Fuel Consumption

(Volvo V70) (gains to be made by modifying surface are limited)

Road surface type	**Fuel consumption relative to Dense Asphalt Concrete 0/16 [%]**
Dense Asphalt Concrete 0/16	0
Porous Asphalt 6/16	- 0.0 (± 3.5)
Stone Mastic Asphalt 0/6	+ 3.4 (± 3.6)
Double-layered Porous Asphalt 4/8 + 11/16*	+ 1.2 (± 3.3)
Cement Concrete, broomed transversely	+ 0.4 (± 3.4)
Cement Concrete treated with a surface epoxy durop	+ 2.7 (± 4.5)
Brick-layered pavement	+ 5.3 (± 6.6)

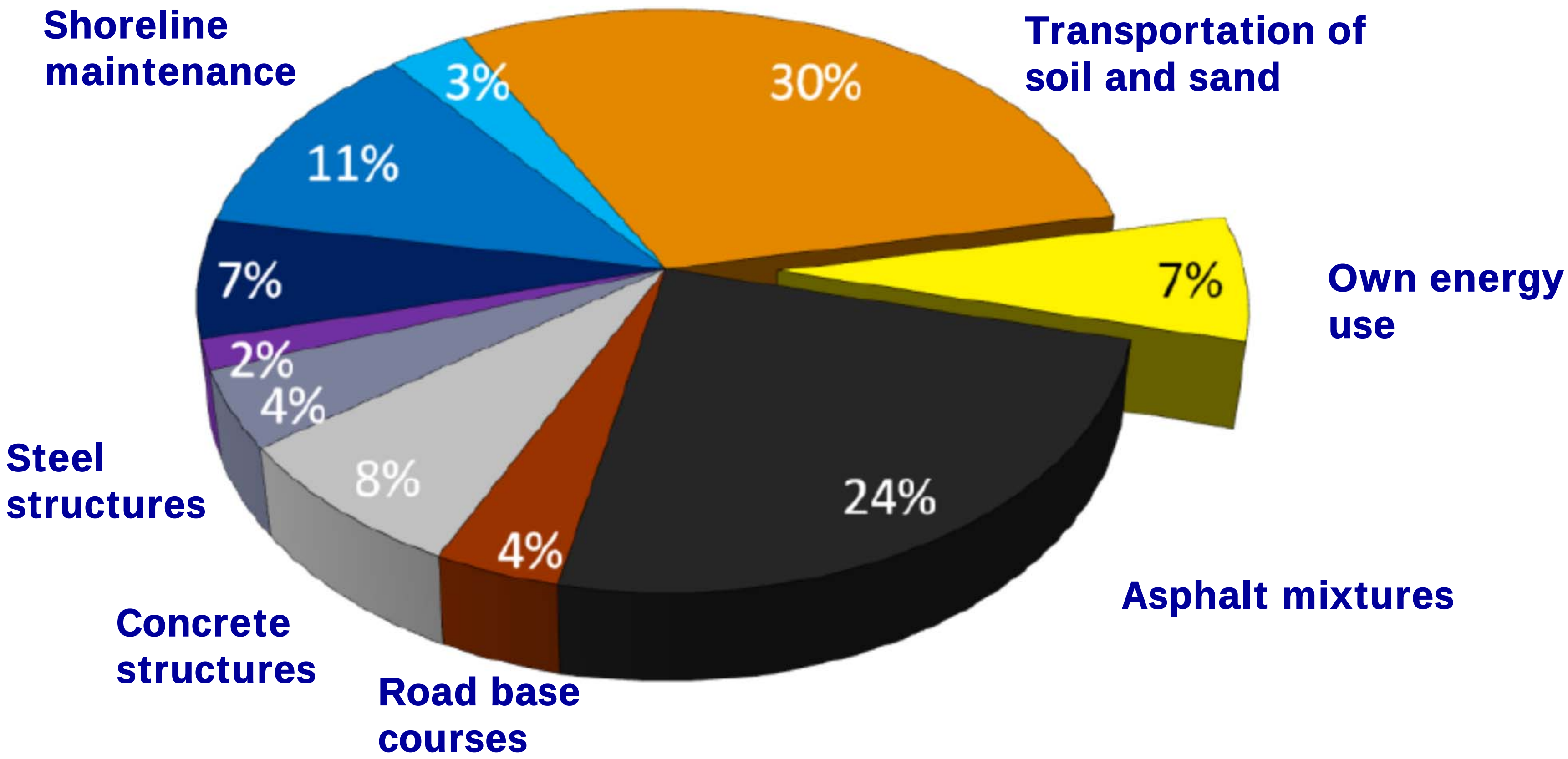
* New road surface; bitumen film still present

Fuel Consumption

- **Study VTI Sweden**
  - passenger car: 1% less on concrete than on asphalt
  - truck: 6% less on concrete than on asphalt
  - influencing factors: texture and deflection
- **Study Japan**
  - heavy duty vehicle driving at 80 km/h on highway:
  1.4 – 4.8% less on concrete than on asphalt

Congres Sevilla

CO_2 Footprint Eng Division MoT, the Netherlands (0.9 Mton/year)



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CO_2 Production Asphalt Mixtures

- **44% production and transportation raw materials**
- **31% production of the asphalt mixture** ***(this is approximately 8% of total CO_2 production by MOT)***
- **18% transportation and laying/compacting asphalt mixture**
- **7% maintenance/milling**

Quickest way to reduce CO_2 is by using less Asphalt Concrete of higher quality

- ***Thinner Structures and Longer Lifetime***
- ***Better Quality***

CAN WE DO THIS?

Thickness design of thinner structures with longer lifetime

- **Endurance limit exists**
- **BUT!!! Reported Endurance Limit Values are specimen properties and NOT material properties**
- **Use of modified mixtures results in higher endurance limit and therefore in thinner structures**

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Endurance Limits at 8 Hz and 20 ºC

Mixture	$S_{m,initial}$ (GPa)	ε_{limit} (10^{-6} m/m)
599-40 (ref)	8.9	50
602-42 (SBS1)	10.8	80
604-41 (SBS2)	10.1	75

Benefits of Modified AC

What is required thickness to achieve tensile strain as low as endurance limit

F = 50 kN; r = 150 mm

Variable thickness; Stiffness of mixtures 40, 41 and 42; μ = 0.35

E = 300 MPa; h = 300 mm; μ = 0.35

E = 100 MPa; μ = 0.35

8” – 9” for sbs structures 12” for reference structure

Conclusion

- **Significant savings can be made by modifying structures and selecting materials with enhanced characteristics**

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Conclusions

- **Variability is caused many times by not optimal logistics and weak control during production**
- **We can get more out of our precious materials and structures by doing a better job**
- **We can get a longer life and reduce environmental impact by doing a better job**
- **Using materials with enhanced characteristics will significantly improve pavement life**
- **Using materials and structures that will reduce fuel consumption of cars is essential**

Conclusions (continued)

- Holistic approach to get environmentally friendly pavements with a long life is essential.
- Optimization is needed taking into account the following factors

  long life

  low noise level

  low energy use

  skid resistance

  reduction green house gasses

Environmentally Friendly
AND
Long Life Pavements

- ***Thinner Structures and Longer Lifetime***
- ***Better Quality***

CAN WE DO THIS?

YES WE CAN!

Thank you for your Attention