Pavement Systems

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contents

- Intro
- Sustainable pavement system
- Variability
- Environment
- Energy (rolling resistance)
- Noise
- Emission/pollution

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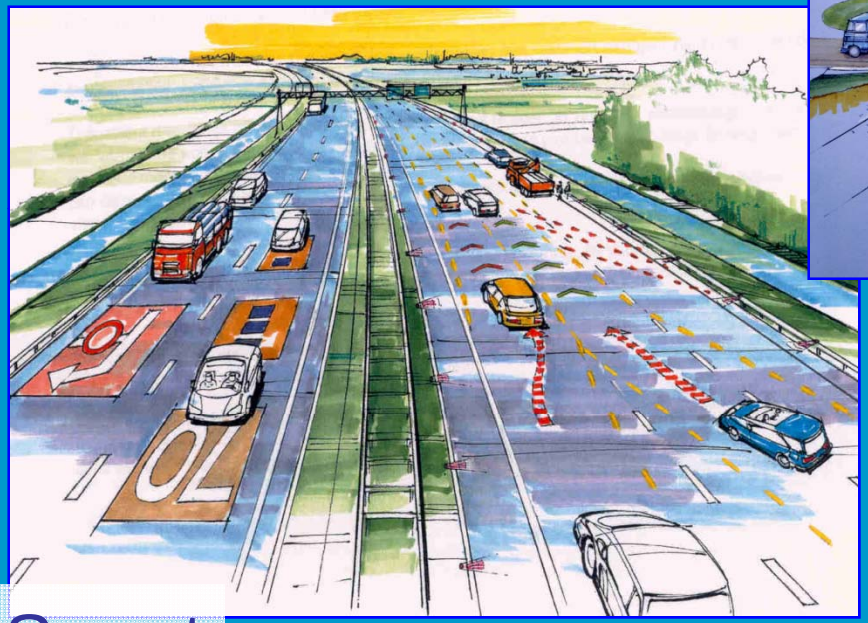
Long term thinking

Multifunctional



Smart

Energy low

Pavement structure design: traditional approach

- Select thickness of covering layers such that stresses in subgrade are reduced to such an extent that subgrade deformations are limited.
- Select materials for covering layers such that no excessive deformation takes place there.

- Designs were based on limiting shear stresses in unbound layers.
- Thin surfacings were used to provide smoothness for driving comfort.

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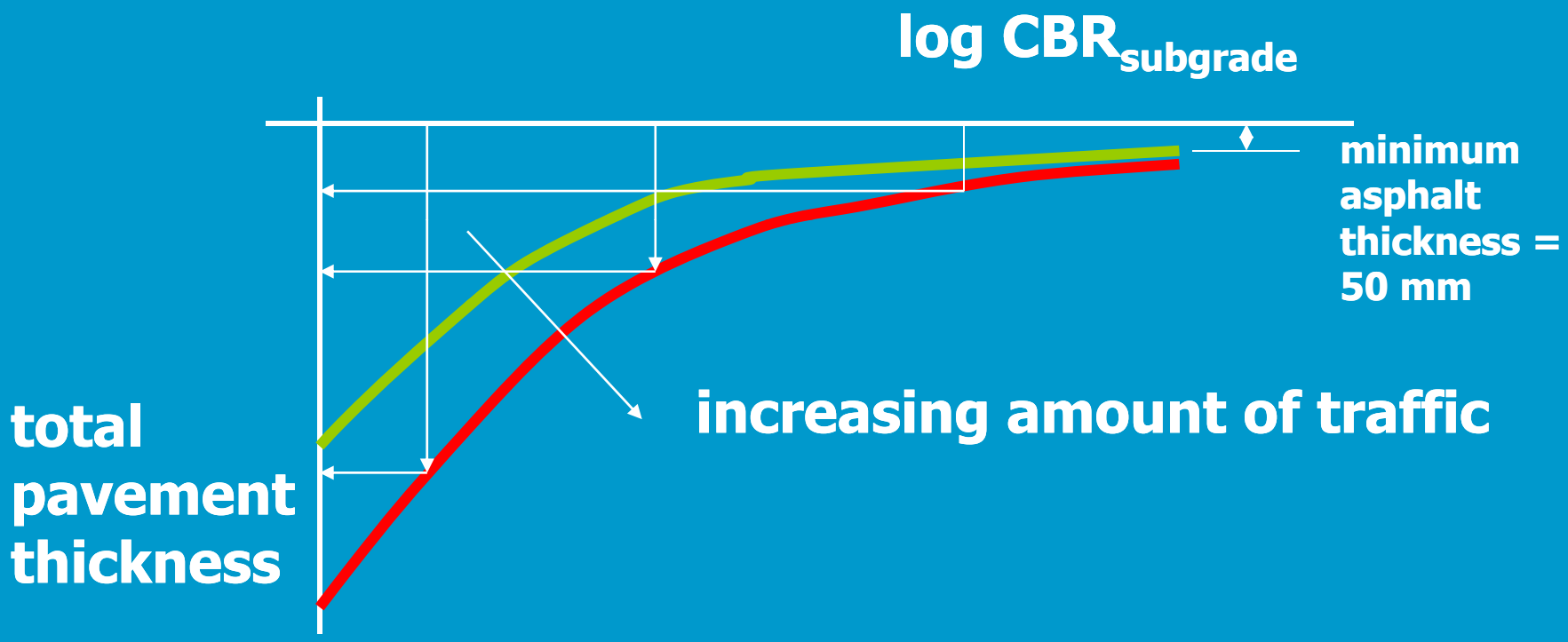
Empirical design charts allowed to determine thickness and CBR of granular base and thickness asphalt layer given $CBR_{subgrade}$



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Modern flexible pavement structures are much thicker and quite diverse …

South Africa	the Netherlands
5 cm asphalt concrete (4%)	5 cm porous asphalt concrete (>20%)
15 cm high quality crushed stone	20 cm aspahlt concrete (6%)
25 cm cement treated subbase	30 cm unbound base of recycled material
CBR ≥ 15%	CBR ≈ 10%

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Pavement Systems in use strongly related to country/local situation: example the Netherlands

- paved area consists for 30% - 35% of small element pavements
- within built-up areas share of small element pavements is even much larger (≈ 55%)

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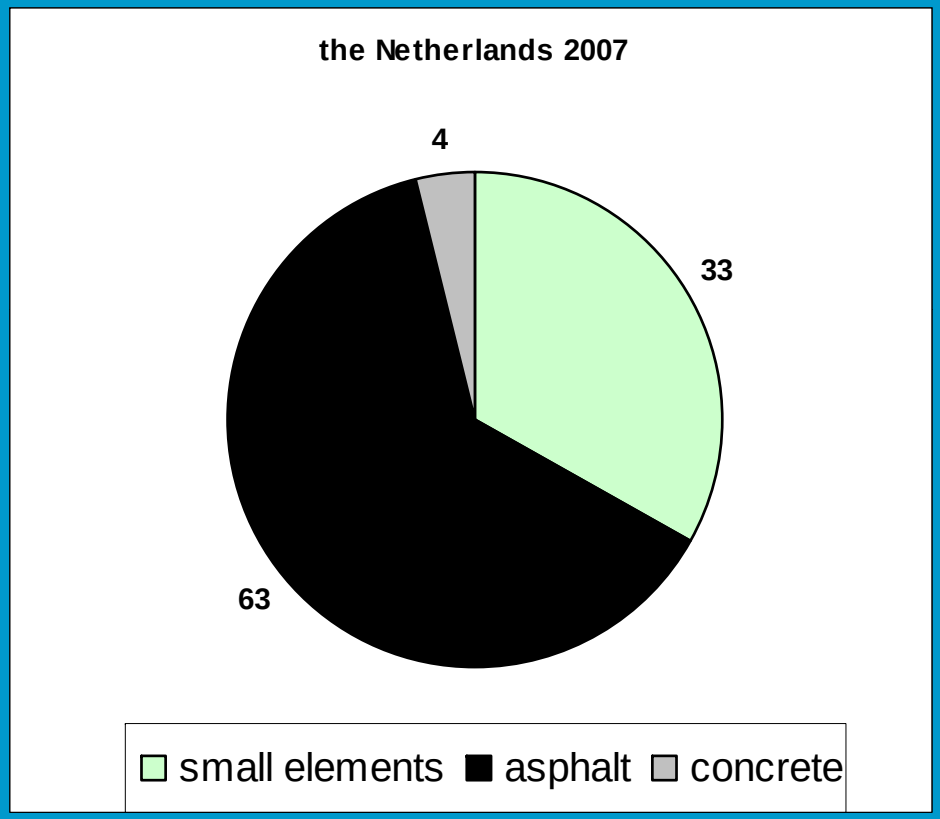
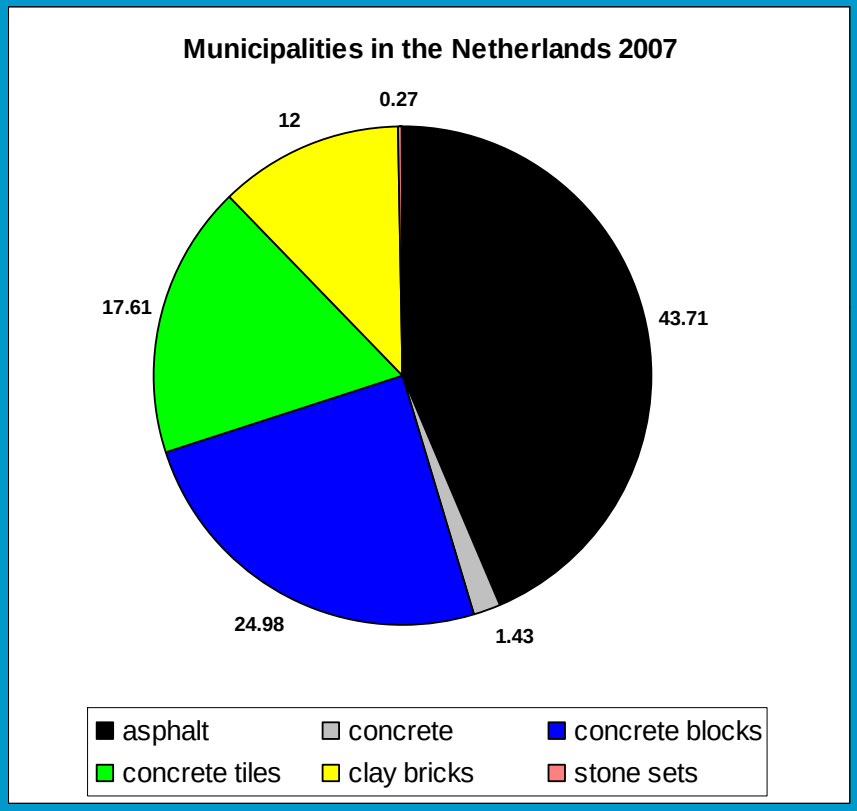
Pavement systems in the Netherlands





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Manual paving: typical Dutch

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Durable and Sustainable Pavement systems

Pavement systems that provide the highest service to the road user with the lowest possible environmental impact.

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Highest Service to the Road User
(definition as used in the Netherlands)

- Lowest hinder to traffic during construction.
- Lowest hinder to traffic during exploitation.

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Lowest Environmental Impact

- Noise, fumes, fine dust, energy.
- Life Cycle Analysis is required.
- Not only the environmental impact of e.g. the production of asphalt should be considered but also the impact of the production of aggregates, modifiers etc should be taken into account.

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Sustainable Pavement systems

- What do we require from our road network.
- Overview of pollution (noise, fumes) and energy demands related to pavement systems and construction.
- Options to reduce pollution and energy needs.
- Topics for today and the future.

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Requirements of Road Networks

- Maximize availability of network.
- Maximize reliability of network in terms of:
  - travel times
  - comfort
  - safety
- Maximize performance predictability of network.
  - increase average quality resulting in longer average pavement life,
  - reduce variability in quality.

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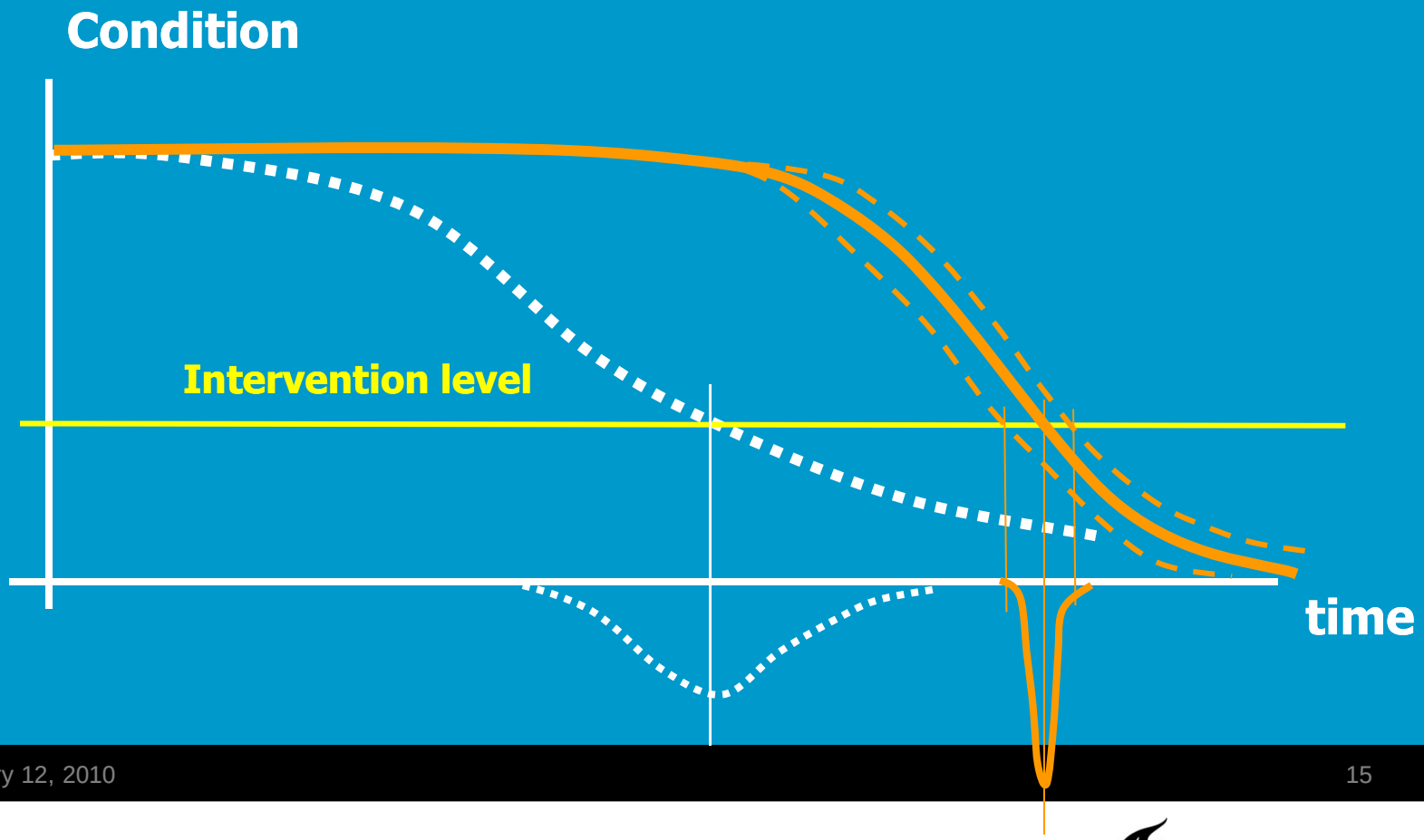
Longer average lifetime and less variation reduces traffic hinder



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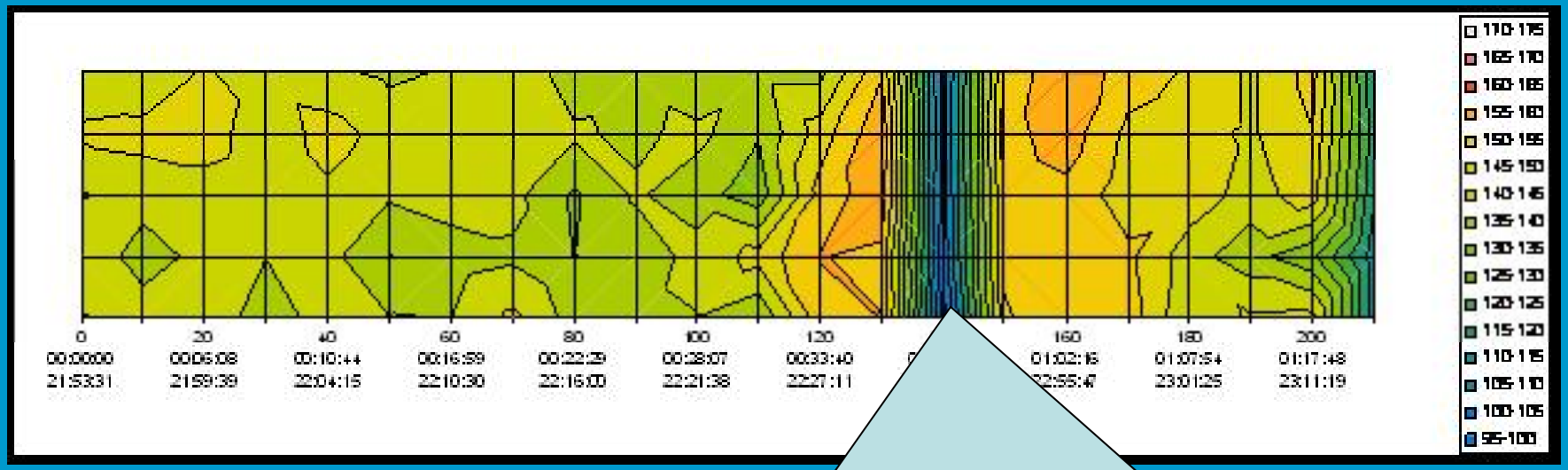
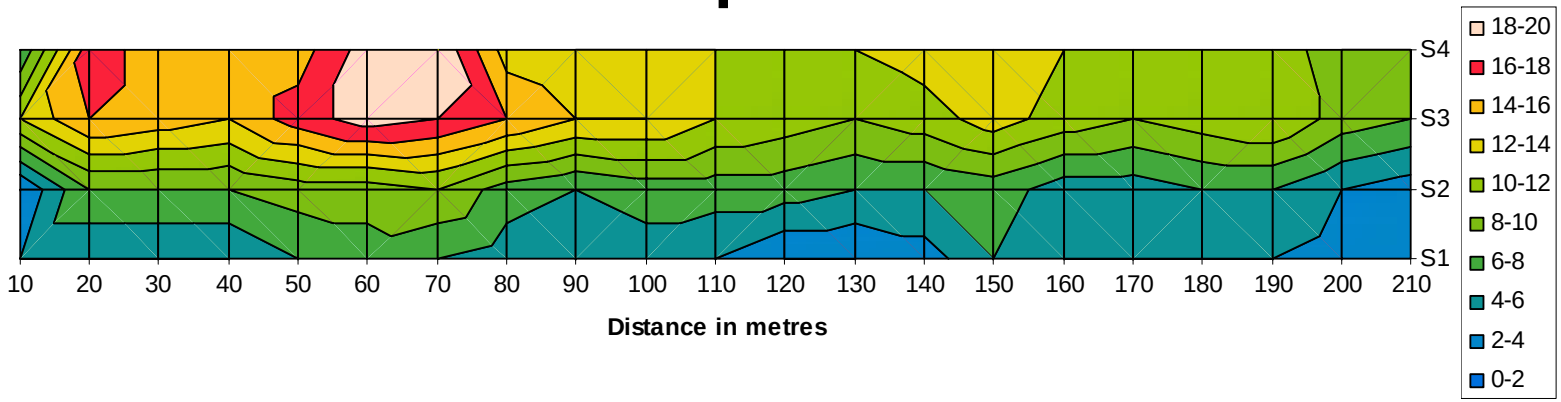


Cooling of the asphalt when the paver has stopped

Roller passes



Source: S.R. Miller, Twente University

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Quick win (example asphalt pavements)

- 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
- Improve existing equipment.
- Computer controlled systems are a must.

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Pavement System (example Asphalt) and Environment

- How much do we produce.
- Main producing countries.
- Status with respect to recycling.
- Low energy asphalt.

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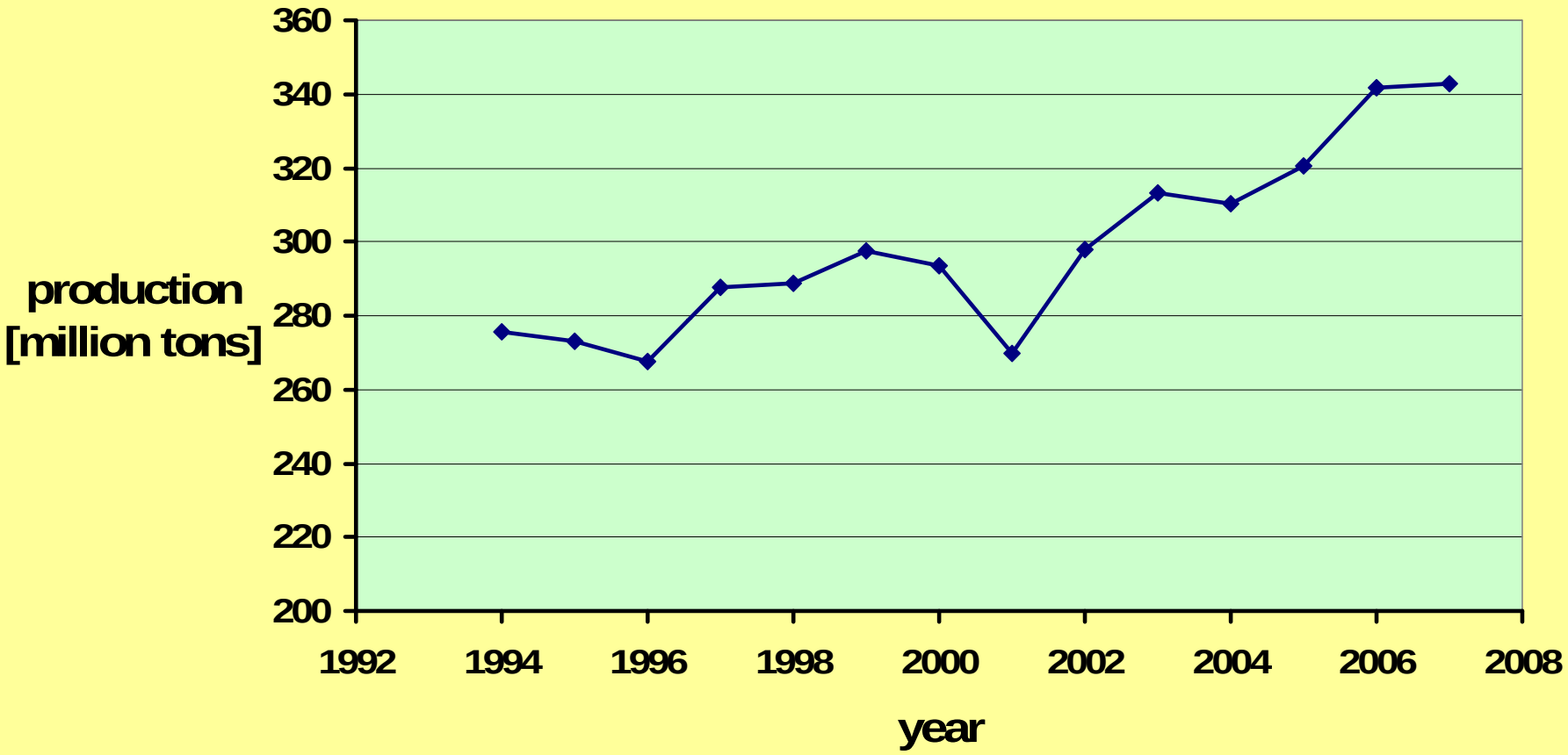
Asphalt Mix Production in Europe



(source: EAPA)

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Production of Asphalt Concrete in Europe (29 countries)

- Total 2007: 342,9 tonnes

France	42,3	Poland	18,0
Germany	51	Spain	49,9
UK	25,7	Netherlands	10,2
Italy	35,1	Turkey	22,2

(source: EAPA)

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Re-use of asphalt mixtures in Europe

Country	Available reclaimed asphalt mix	% re-used in hot mix	% re-used in cold mix	% of new hot mix production
Germany	$14 * 10^6$	82	18	60
Spain	$2.25 * 10^6$	8	4	3.5
Italy	$14 * 10^6$	18	2	
France	$6.5 * 10^6$	13	< 2	< 10
Norway	$0.59 * 10^6$	7	26	8
Netherlands	$3 * 10^6$	75		63

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Quick win? (unless..)

- Re-use of old asphalt is a well developed technique; it is widely applied in a number of countries.
- Re-use of old asphalt is not yet a general applied technique.
- Re-use and recycling need firm support and should be enforced by legislation.

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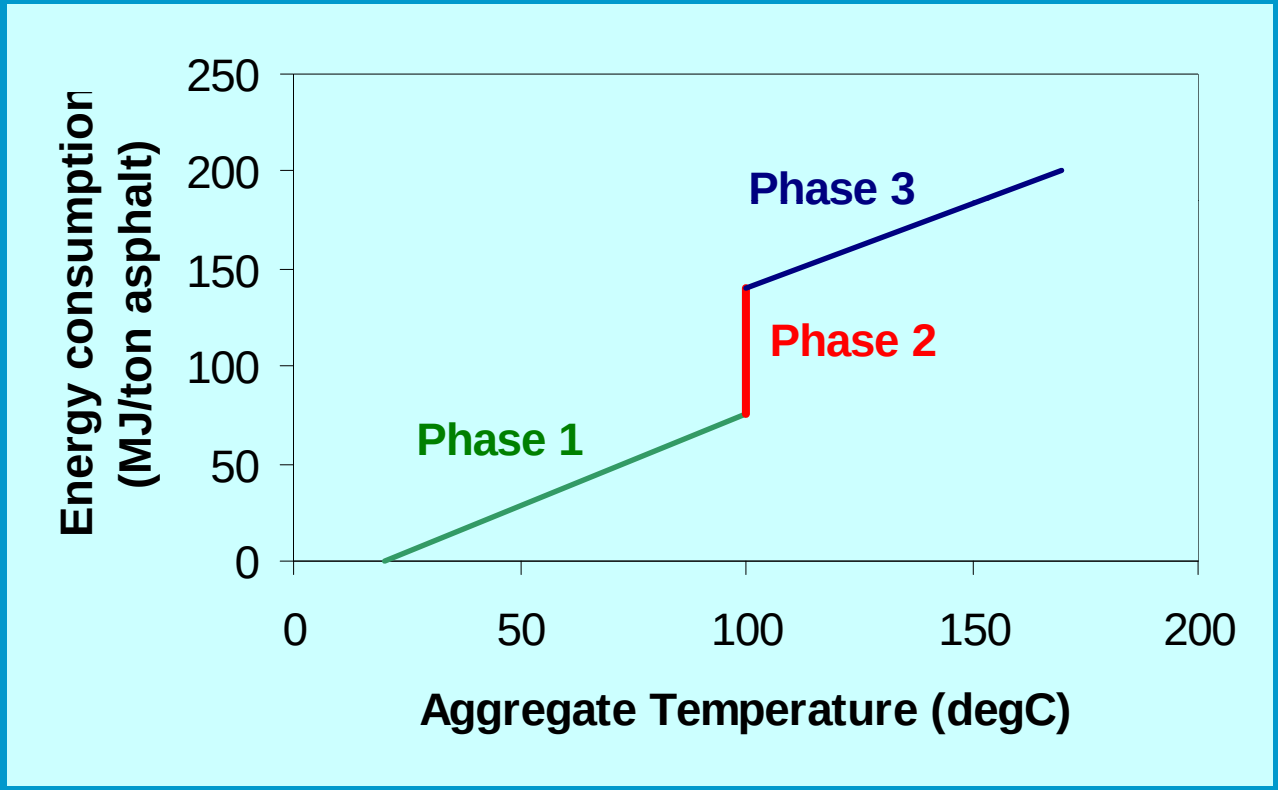
Asphalt: reducing Production Temperatures reduces Energy Needs and emissions



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Production of Aggregates in Europe
(18 countries)

- 2800 million tonnes per year (≈ 50% crushed rock, ≈ 5% recycled aggregate, ≈ 45% gravel and sand)
- 2700 sites
- a road uses 30 000 tonnes per km

Germany	526	UK	257
Spain	438	Poland	148
France	402	Finland	98
Italy	358	Austria	95

(source: European Aggregate Association)

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Aggregates in pavement system

- Re-use and recycling of e.g. concrete and masonry rubble is at embarrassing low level.
- Some countries are really front runners; in the Netherlands 90% of the concrete/masonry rubble is recycled as base course for roads.
- Much can be gained.

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Energy consumed in procuring materials and in executing primary construction activities		
Material procurement / Construction activity	Unit	Energy consumed (Mj)
Material procurement		
Graded crushed stone (GCS)	Mj / t	50
HMA manufacture	Mj / t	30
Cement	Mj / t	70
Bitumen	Mj / t	60
Material haulage	Mj / t km	1
Construction activity		
Milling [1]	Mj / t	5
In situ recycling / stabilising	Mj / t	10
Processing aggregate layer	Mj / t	66
Ditto per m² for 150mm thick layer	Mj / m²	10
Compacting and finishing layer [2]	Mj / m²	10
HMA paving and compaction	Mj / t	20

Source: Dave Collings

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Energy Consumption in EU-27 (2007)

Industry	Households	Agriculture	Transport	Services	Other Sectors
28%	25%	2%	33%	11%	1%

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Energy Consumption of a Pavement System (Ecoles des Mines 2002)

- 1 km 2 x 2 lane road
- 30 years lifespan
- traffic class 6
- 25 million heavy goods vehicles
- 100 million private cars
- total energy consumption 1430 TJ
- 2% is used for construction and maintenance

(source: EAPA)

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Contribution pavement system

- Although very important (cold in place recycling), savings which can be realized by construction of pavement systems are limited.
- Main savings can be obtained by reducing energy needs of trucks and cars.
- What could be contribution of Pavement system?

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Road Surface and Fuel Consumption
(Volvo V70)

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

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Pavement systems: rolling resistance

- Much more work should be done in the development of rolling resistance reducing wearing courses.
- It looks like some noise reducing surface layers are not really reducing rolling resistance!

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Noise in Europe (2000 data)

- More than 44% of the EU-25 population (210 million) is regularly exposed to noise levels higher than 55 dB(A).
- 25 million are seriously annoyed.

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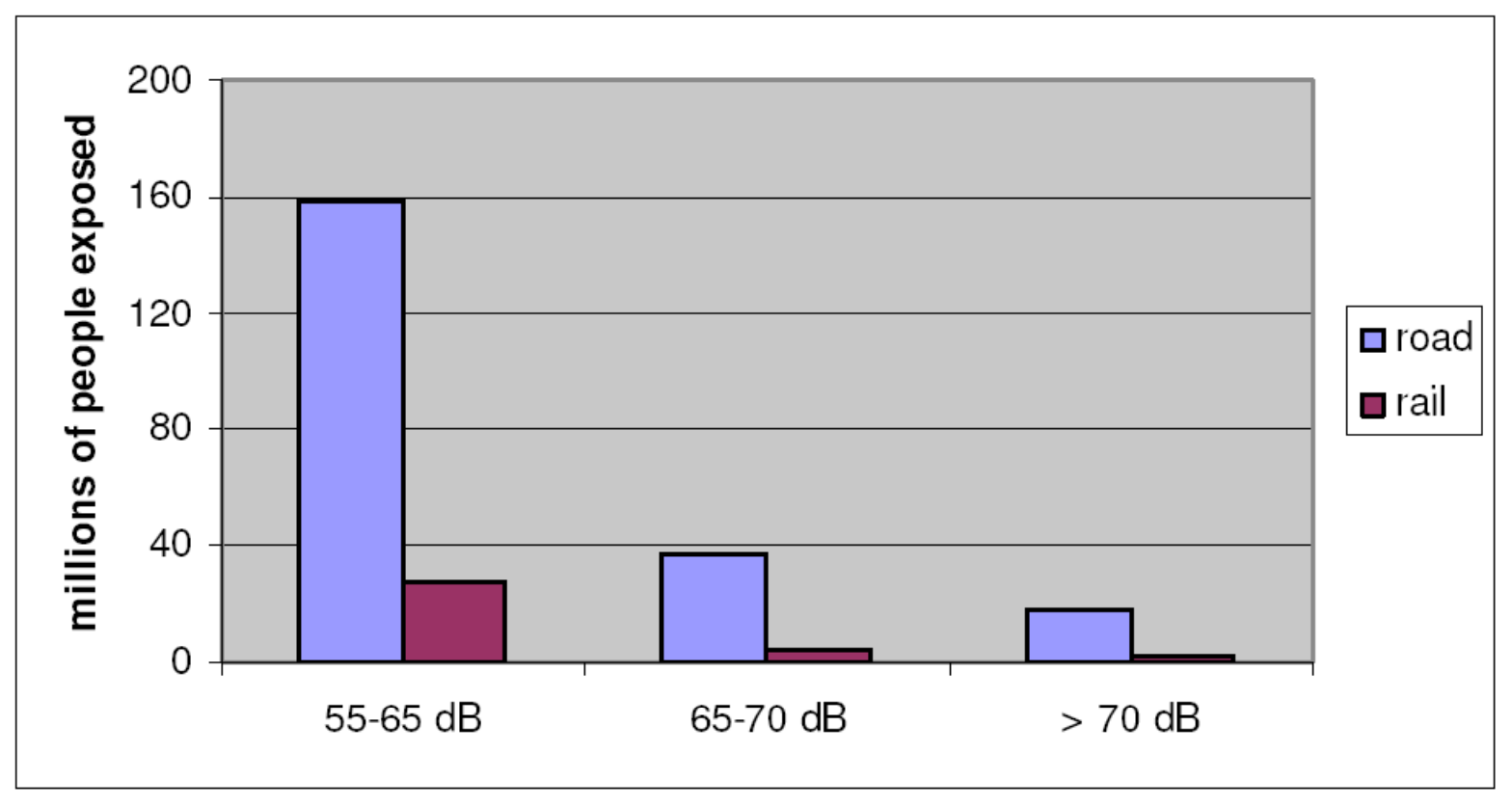
Noise in Europe (2000 data)



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Pavement system and noise

- Noise reducing pavement Systems are important.
- Noise reducing layers not always possible because of harsh climatic (winter) conditions (snow removal, salt, low temperatures).
- Durable (long life) solutions are needed.
- Also rolling resistance as well as skid resistance are of importance.
- Holistic approach is needed. Silent surface – silent tire – durable wearing course with low rolling resistance – skid resistance.

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Air Pollution and Emissions in the Netherlands

- NMVOC = volatile organic compounds excluding methane; smog generating, sometimes carcinogenic
- SO_2 = causing acidification
- NO_x = causing acidification and smog
- NH_3 = causing acidification
- PM10 = particle matter smaller than 10 μm; penetrates deeply into lungs; detrimental to health

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Pavement systems and air polution/emissions

- Traffic is major contributor to air pollution.
- Contribution of the building materials industry seems limited.
- Contribution of Pavement systems in reducing pollution?
  - smooth roads to reduce fuel consumption,
  - catching PM10,
  - catching NO_x.

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Sustainable and Durable Pavement Systems

- Improved production and construction techniques including improved workmanship (e.g. through computerization).
- Long life wearing courses produced at low energy and emission levels.
- Silent and durable wearing courses with low rolling resistance.
- Increased re-use of RAP and recycling of building materials in general.
- Further development of emission controlling systems.

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Green Purchasing Policy Dutch RWS as per 2010

- LCA is the most recognized and scientific method to measure environmental performance
- With a reduced impact for design and construction based on LCA, the bid will get a higher rating
- LCA needs to conform to NEN 8006
- 2 models are accepted as tools for proof to meet this requirement

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Change?

- Yes we can

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2030

For this price-bracket, a jolly good road