Aalto University

Alternative road materials and design concepts – Finnish experiences

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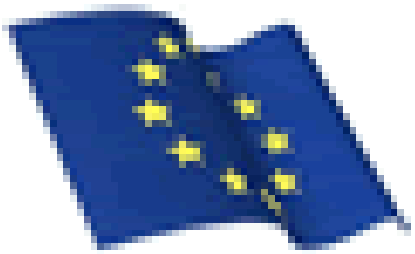
Eesti tuleviku heaks

Contents of the presentation

- Finnish design and construction standards and guidelines in 2013
- Alternative (new?) materials or methods used in pavement/road layers
- Design methods for alternative pavement structures

Different standards to follow



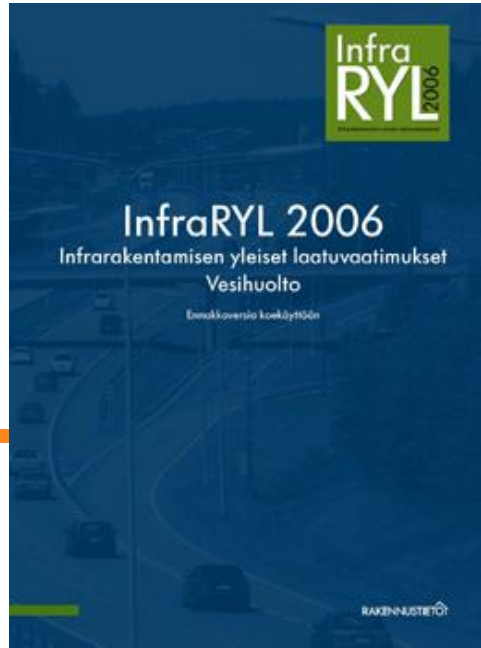
- **Design standards** – Eurocode system for supporting structures and geotechnics of infra structures, not for pavement design
- The **execution and product** standards will be taken into use after their approval process
- Also the ground investigations, surveys and measurements are included in the standards
- No standard so far for the earth construction works – discussion to start preparation

Finnish design and construction standards and guidelines

- Eurocode design system is mandatory in building construction. Partly also in infra sector.
- All builiding materials and products, which have harmonized product standard must be CE-marked after 1.7.2013!
- Most of the infra construction products have product standard (aggregates, drainage systems, piles, asphalt,…)
- Voluntary standard approval and other methods from older system can be used otherwise

National applications of the general quality requirements for infra construction

- InfraRYL2006 Part 1- Roads, railways and fields
- InfraRYL2006 Part 2 – Systems (e.g. water and sewage)
- InfraRYL2006 Part 3 – Bridges and structural parts
- InfraRYL2006, Part 4 - Sport and recreation areas
- Printed and eletronical versions
- Only in Finnish
- **More information www.rts.fi/infraryl/**



Standards of asphalt works in Finnish

- SFS-handbook165, includes all standards dealing with asphalt and paving works
- Parts 1 and 2 testing methods
- Part 3 material requirements
- The asphalt norms 2008 delivered by PANK includes Finnish applications
- Asphalts should be CE-marked

Alternative materials and new solutions for road / pavement structures

Need to have competence qualification systems – for example geotechnical designers of infrastructures

New updated guidelines and examples calculations are needed

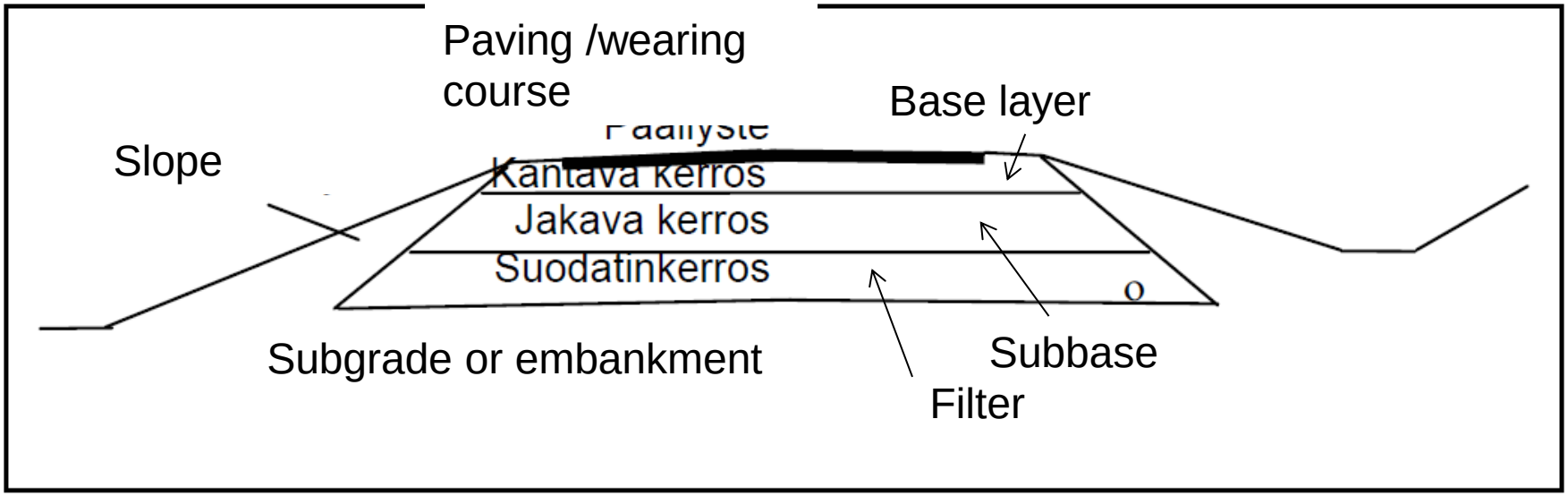
Need to update design programs

The design costs will be bigger at least in bridge and geotechnical design

The price of the ground survey will increase

The utilisation of alternative materials in pavements

- Unbound granular materials or stabilized layers including treatment of the subgrade
- Very low-quality materials in other parts (slopes, noise barriers, other fillings)



Alternative materials used in pavement (road) layers

- **Metallurgical slags (e.g. Blast furnace slag =BFS)**
- **Waste from construction industry and projects**
- **Ashes from energy industry and end product of desulphuration**
- Process waste from forest and pulp industry
- Used tyres and foamed glas
- Side products (dressing sands and others) from ore and extractive industry (the location of the mines)
- **Surplus of the infra construction**
- **Used (recycled) asphalt**

Recycled asphalt

- Finland is pioneer in the recycling of asphalt
- Besides recycling in paving, crushed asphalt can be used:
  - in the base layer of the low-volume roads
  - In temporary pavings
  - Yards and storage fields
  - As one component of stabilisation binders
  - In the edge areas of embankments

Metallurgical slags

- Produced in big amounts, locations problem
- Trade marks: BFS and OKTO-products
- Some slags will bind by themselves, yet they can be excavated from the pavement
- Some slags are under waste legistation (heavy metals)
- BFS and OKTO: Good bearing capacity, even better than classic crushed materials
- BFS and OKTO: can be used also an isolating or lightweight material

Crushed concrete

- Best quality for the concrete industry by-product
- Also from remolition projects
- Crushed concrete waste: steels are removed carefully
- Properties and qualification system
- Binds itself, can be excavated

a)	Rakei-suus** [mm]	Lujittu-minen	Routi-vuus	E-moduuli [MPa]
BeM I	0-45	Lujittuu	Routimaton	700
BeM II	0-45	Lujittuu	Routimaton	500
BeM III	0-45	Epävarmaa	Routimaton	280
BeM IV	Vaihtelee	Ei lujitu	Vaihtelee	≤ 200*

* harkittava tapauskohtaisesti ottaen huomioon mahdollinen routivuus
** Tielaitoksen rakeisuusohjealue 0/45 /7/
E-moduulien määritys on esitetty raportissa “Betonimurskeen mitoitus-parametrit” /1/

Suitability for road structures

c)	Eri betonimurskelajitteiden soveltuvuus		
	Kantava Kerros	Jakava kerros	Penger-täyte
	I, II, (III)	(I), II, III, (IV)	(I-III) IV

Base layer **Subbase** **Embankment fill**

Good experiences even for long-term structures (more than 17 years) reported in new Master thesis
Material can achieve in general higher stiffness than for crushed materials, long-term performance is good

Ashes

- Fly as
- Fly as
- Coars
- Heav
- Can c
- Frost
- Long-
- Binds

Fly ash **Bottom ash**

Ominaisuus	Olosuhde	Lentotuhka	Pohjatuhka
Rakeisuus [mm]		0,002–0,1 (siltti)	0,002–16 (hiekka)
Optimivesipitoisuus [%]		20–50	16–24
Maksimikuivairtotiheys [kg/m³]		1100–1400	1000–1500
Märkäirtotiheys tiivistettynä [kg/m³]		1300–1500	1250–1800
Kitkakulma [°]	lujittumaton	28–36	39–53
	lujittunut	49–77	
Koheesio [kPa]	lujittumaton	23–47	10–30
	lujittunut	64–490	
Vedenläpäisevyys [m/s]	lujittumaton	10^{-7}–10^{-6}	10^{-6}–10^{-5}
	lujittunut	10^{-8}–10^{-6}	
Hehkutushäviö [%]		1–5	-
Lämmönjohtavuus [W/mK]	sula	0,4–0,6	0,9
	jäätynyt	0,8	
Segregaatiopotentiaali [mm²/Kh]		0,05–5	<0,2

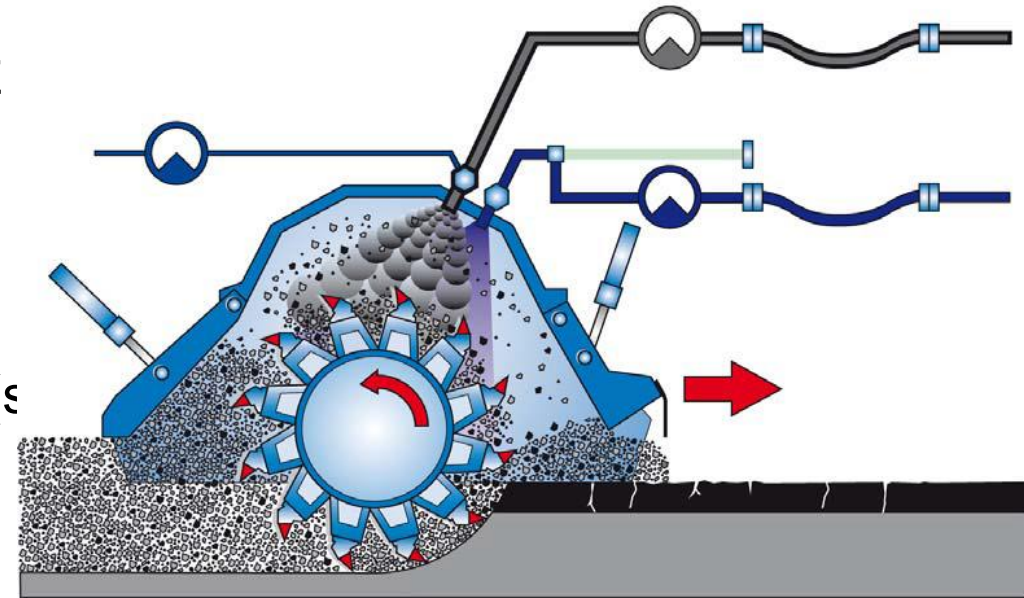
Stabilisation of pavement layers (base + subbase)

- Finnish research project ended 2007
- Laboratory studies and test structures
- http://alk.tiehallinto.fi/thohje/pdf/2100055-v-07paallysrakenteen_stabilointi.pdf
- Final report in Finnish

- Layer stabilisation is not widely used in 2012, because government is not investing for road maintenance
- Full-depth reclamation > 1 Mm^2/year

Stabilisation of pavement layers methods

- **Stabilisation with foamed bitumen**
- Stabilisation with bitumen emulsion
- Remix-stabilisation
- Composite stabilisation (bitumen + cement)
- Stabilisation with blast furnace slag BFS (might include activator = cement)
- Stabilisation with cement
- For existing structures:
  - Premilling (esijyrsintä)
  - Milling with stabilisation
  - **Full-depth Reclamation** (s



Stabilized layers: requirements and material properties 1

- InfraRYL2006, part 1
- Mixing on-site or mixing station
- Bearing capacity, in general better than for unbound:
  - Bitumen stabilisation: more flexible than others
  - Cement stabilisation: quick hardening, very stiff
  - BFS: slow hardening, relatively stiff
- Deformation properties better than unbound:
  - Bitumen stabilisation: optimisation of amount (hot weather-> weak, cold -> resistance against water will be weak)
  - Composite stabilisation: optimum
  - BFS: slow hardening, self-rehealing

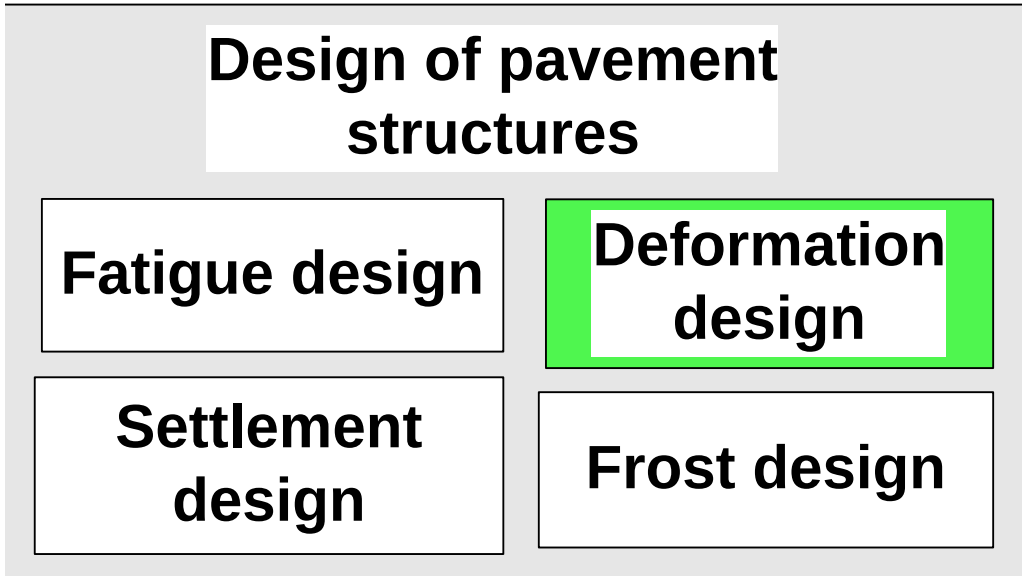
Stabilized layers, material properties 2

- Better frost susceptibility, does not correct the subgrade frost heave, evens the deformations
- A proper drainage is needed
- For the aggregate grain size distribution is important
- Adding of new aggregate material to old structures
- For rehabilitation cases: stabilization can be done lane by lane, disturbs traffic much less than other methods
- Finnra does not allow to use cement stabilisation

- **Stabilized layers MUST BE COVERED WITH ASPHALT**

Pavement design

Pavement structure design components



Service life of the structure
Life cycle costs
Selection of the structure

Finnish design practi

- Settlements are calculat
  are used (ground improv
- Frost design -> allowable
  thickness of the layers
- Fatigue design bases on
  Tabulated values for the
  values for alternative ma
- Deformations are not ca
  usually with thin paveme
  fields
- http://alk.tiehallinto.fi/thohje/p
  04tierakenteensuunn.pdf

TIEHALLINTO

Tierakenteen suunnittelu

Kuormitusluokan 10,0 (entinen 1) tavoitekantavuudet ja päällysteen vähimmäispaksuudet

KKL-luokka Vaiheen rakentamisajankohta	10,0 AB	10,0 AB	10,0 AB
Tavoitekantavuus (0…6 v.) ja	420 MPa	380[2] MPa	490 MPa
päällysteen kokonaispaksuus	170 mm	150 mm	130 mm
Tavoitekantavuus (0…2 v.) ja	360 MPa	325 MPa	
päällysteen kokonaispaksuus	140 mm	120 mm	
Tavoitekantavuus (0 v.) ja	285 MPa	270 MPa	420 MPa
päällysteen kokonaispaksuus	100 mm	90 mm	100 mm
Tavoite kantavan päällä (MPa)	160 MPa	160 MPa	265 MPa
Kantavan laatu	M tai MHST	BST	SST

Conclusions

- CE-marking is needed after 1.7.2013
- New standardisation -> need for new guidelines
- The use of alternative materials in general is increasing
- Good solution is to combine alternative materials together with reinforcement

- The readily calculated structures can not properly take into account alternative or lightweight materials or structures including reinforcements

Thank your for your attention!