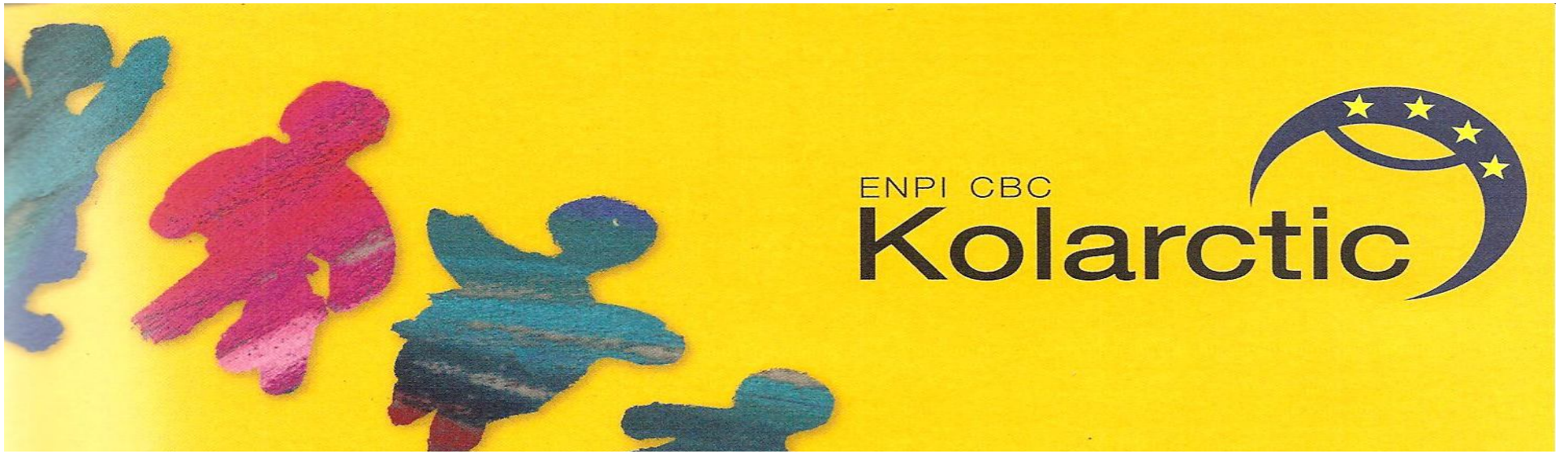

Barents Case Arkhangelsk

Annele Matintupa,
MSc. Civil Engineering
Roadscanners Oy,
Finland

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The Pilot Road Section

The regional low volume road “Arkhangelsk - Rikasikha – Onega”

For more detailed study the two pilot road sections with typical were chosen:

1. “Arkhangelsk - Rikasikha – Onega” road, km 47- 49 (near Verkhovka river bridge)
2. “Arkhangelsk - Rikasikha – Onega” road, km 57- 59

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The Goals for the Road Pilot

- Compare road condition management problems in Archangelsk are with typical problems in ROADEX countries

- Perform tests with ROADEX design methods with different structural solutions

- Calculate the effect of heavier truck options within different structural solutions

- Make recommendations for the most sustainable solutions

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Typical low volume road problems in Archangelsk area:

- Low bearing capacity especially during spring thaw
- Poor road drainage, too thin road structures
- Poor quality base course materials
- Lack of good quality road materials
- Water and frost susceptible subgrade materials, silt, peat
- Dusting
- Rutting
- Uneveness, settlements
- Roads are too wide
- Washboarding, etc.

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Observations from Pilot Sections

"Arkhangelsk - Rikasikha – Onega"

- Bad washboardning – low driving speeds

- Dusting (poor grading of material)
- Road width 12m, which is 4 m wider than the design width (8m), additional 2 m each side

- Shoulder: 10…60 cm sand/vegetation verges keeping the water in road area during rains and snow melting time in spring.
- Uneven gravel road wearing course thickness
- Road subgrade is silt or sandy silt, in spring thaw weakening and after heavy rains heavy trucks cause permanent deformations – Mode 2 rutting. Also peat subgrade exists.

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Test Road Problems

Dusting and washboarding

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Test Road Problems

Problems with road widening and verges

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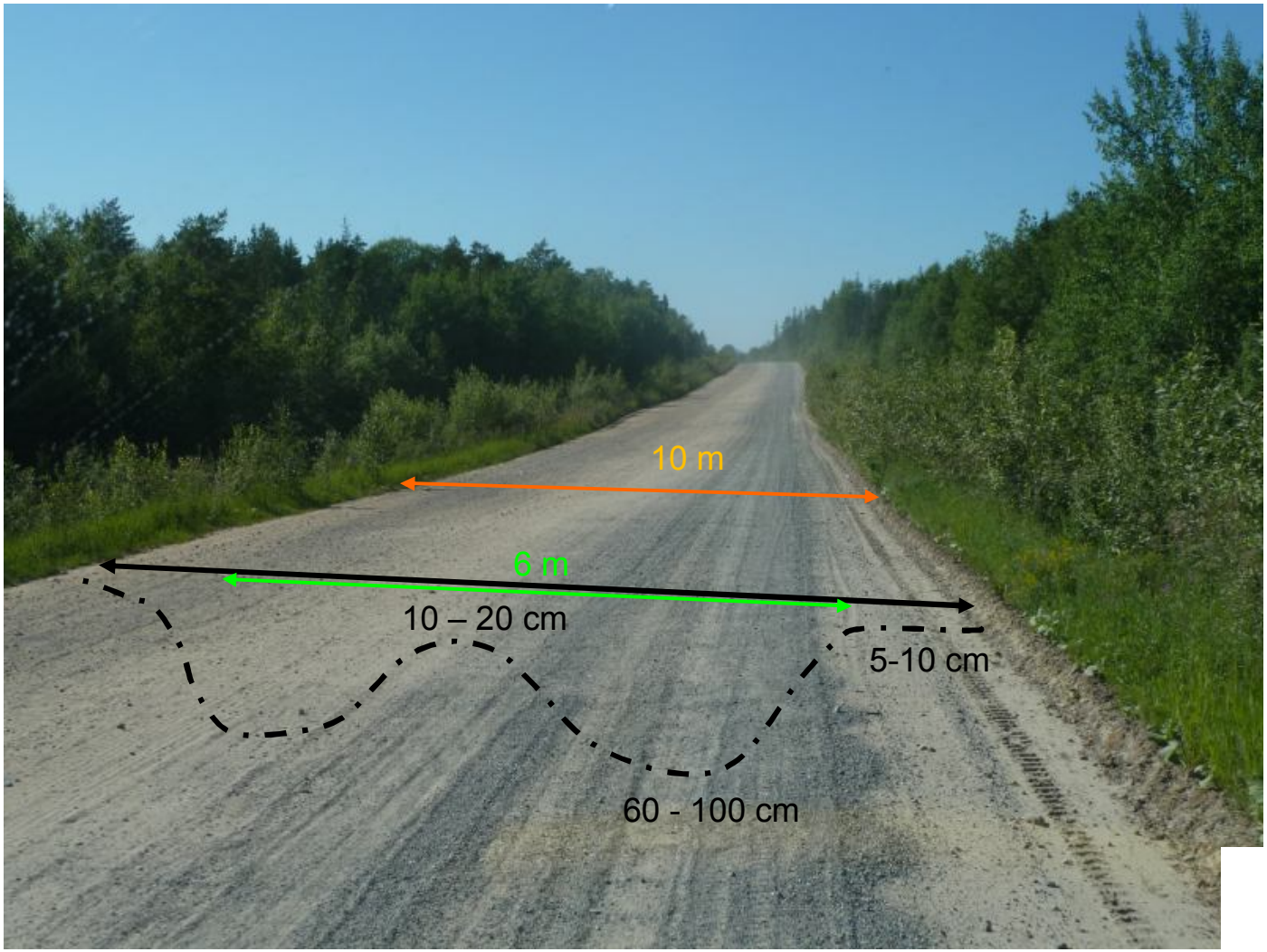
Test Road Problems

Mode 2 Rutting and widening



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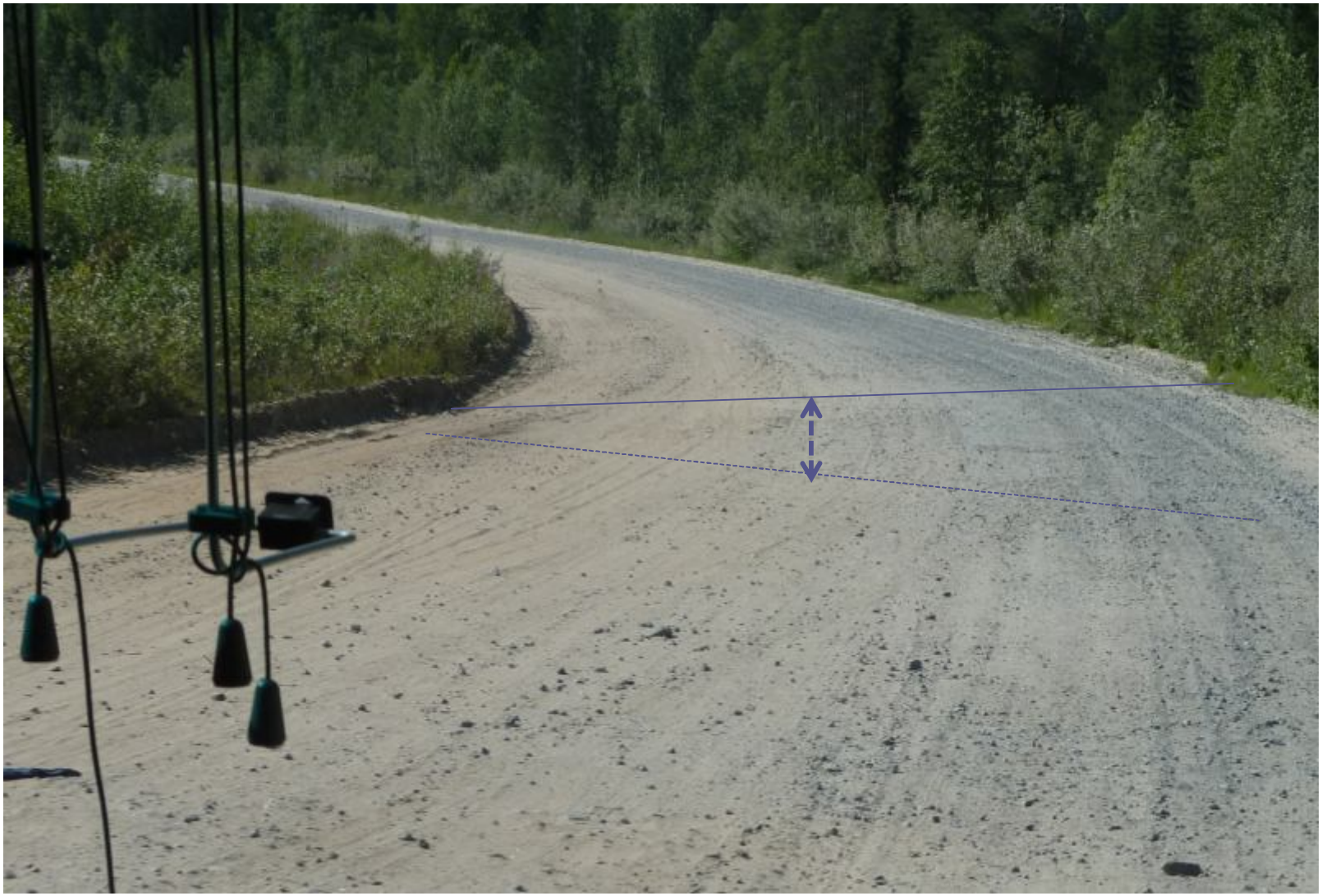
Test Road Problems

Thin structures especially in inner curves



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Test Road Problems

Settlements

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Survey Techniques Used

- Visual inspections and digital videos
- Sampling (on chainage km 48 and 58 km)
- Laboratory tests
  - Grain size distribution
  - Water adsorption index
  - Analyses with Bisar ® software for deflection analysis

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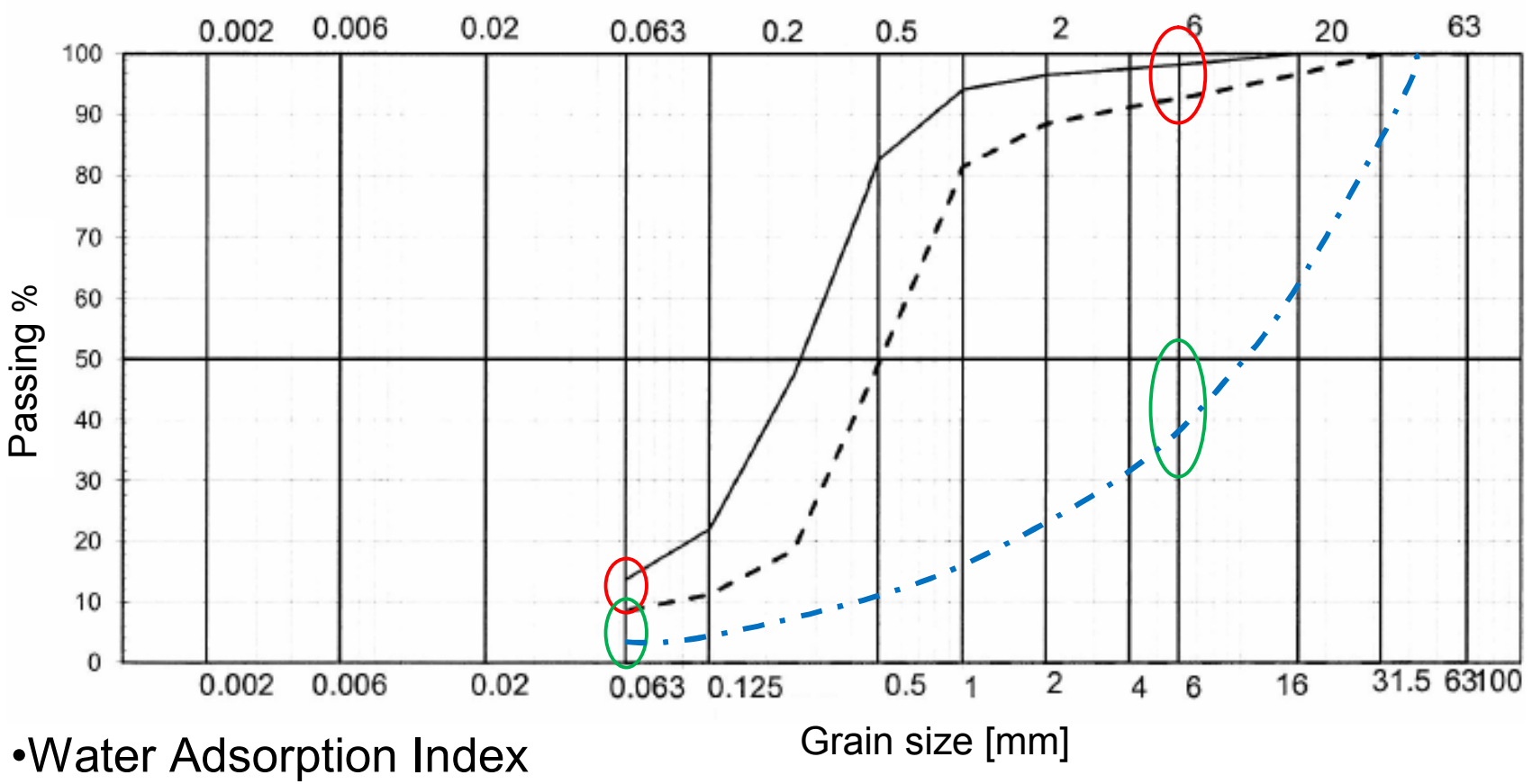
Results from Laboratory Analysis

- Grain Size Distribution, the relative amount of particles <0,063mm
  - 13,6% (chainage km 48) ————
  - 8,5% (chainage km 58) ----------



- Water Adsorption Index
  - 5,72% (chainage km 48)
  - 5,42% (chainage km 58)

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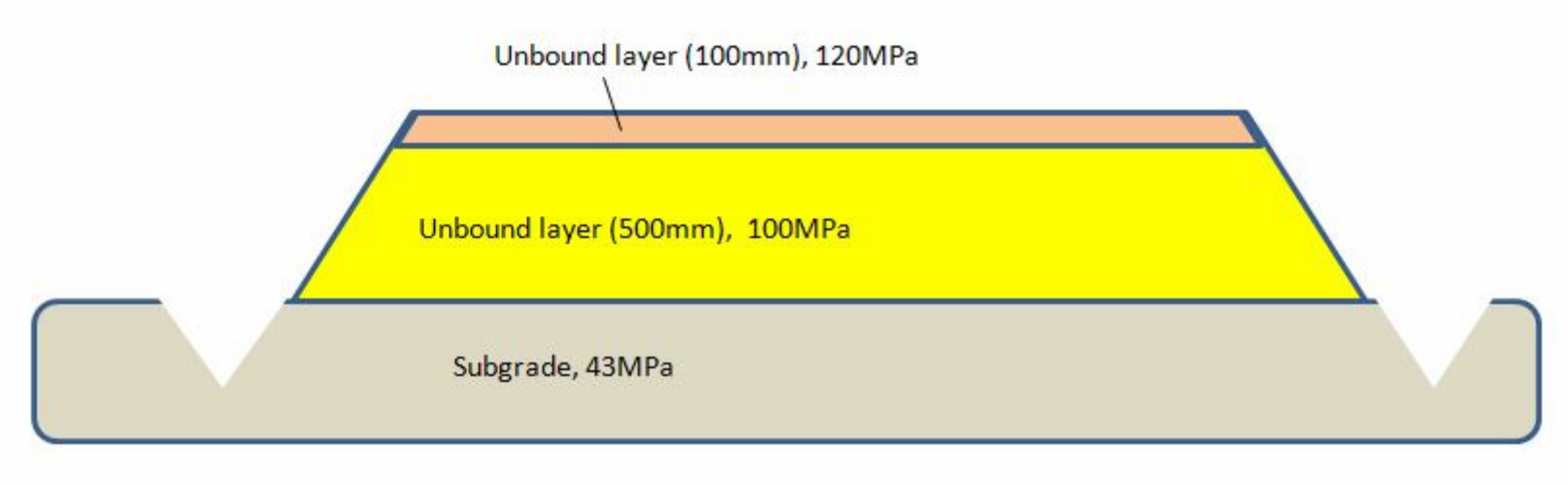
Existing Road Structure and Moduli Values

Km 47-49



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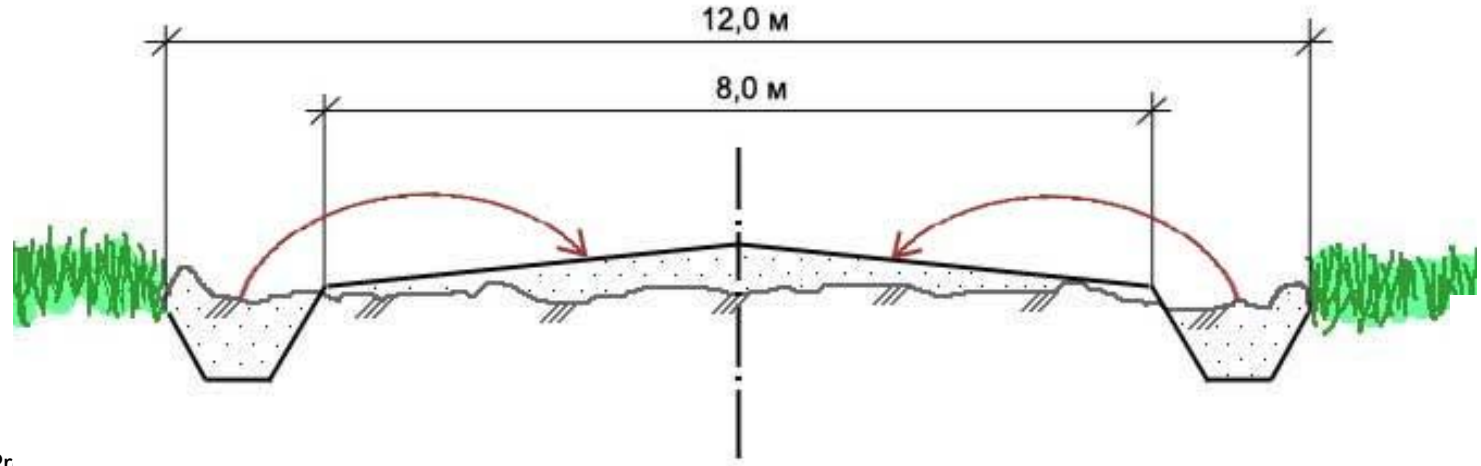
The First Measures

•Road width narrowing within normal 8m
•Excess width shall be eliminated with means of cutting clear shaped slopes and ditches
•Correction of gravel road shape using existing material
- ➢Before using the old material, the condition of it should be checked with laboratory tests
- ➢Removal of organic material (roots, etc.).
- •The drainage should be improved

•In early spring the snow walls on the shoulders shall be pushed away to the ditches to prevent accumulation of melted water on the surface and provide even thawing of the road along its width.



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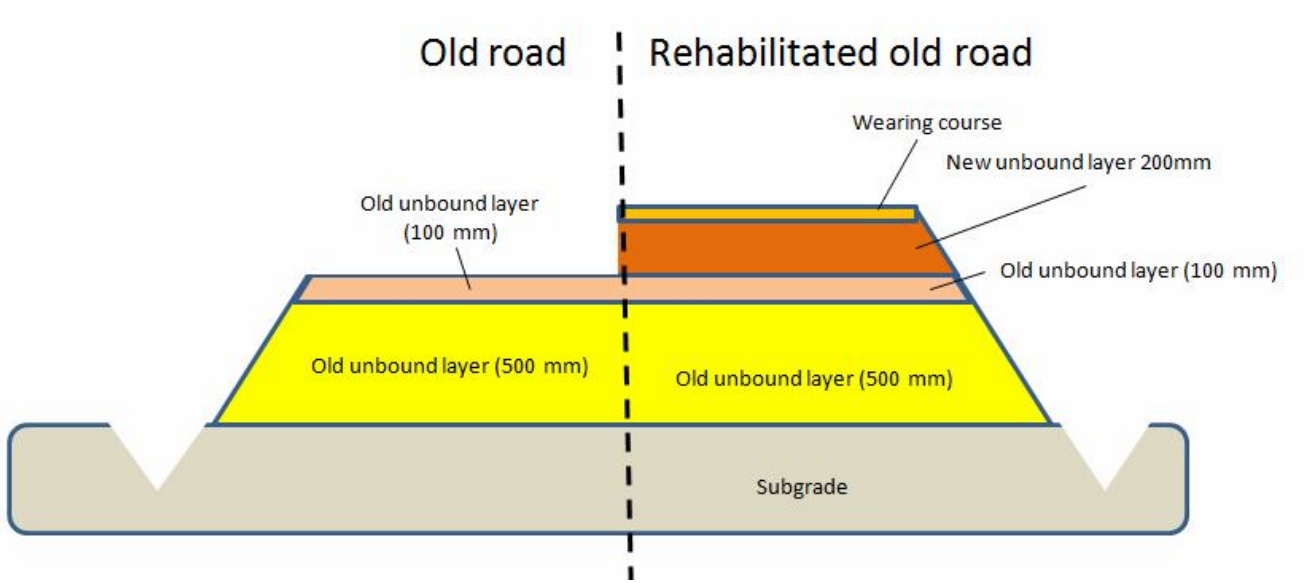
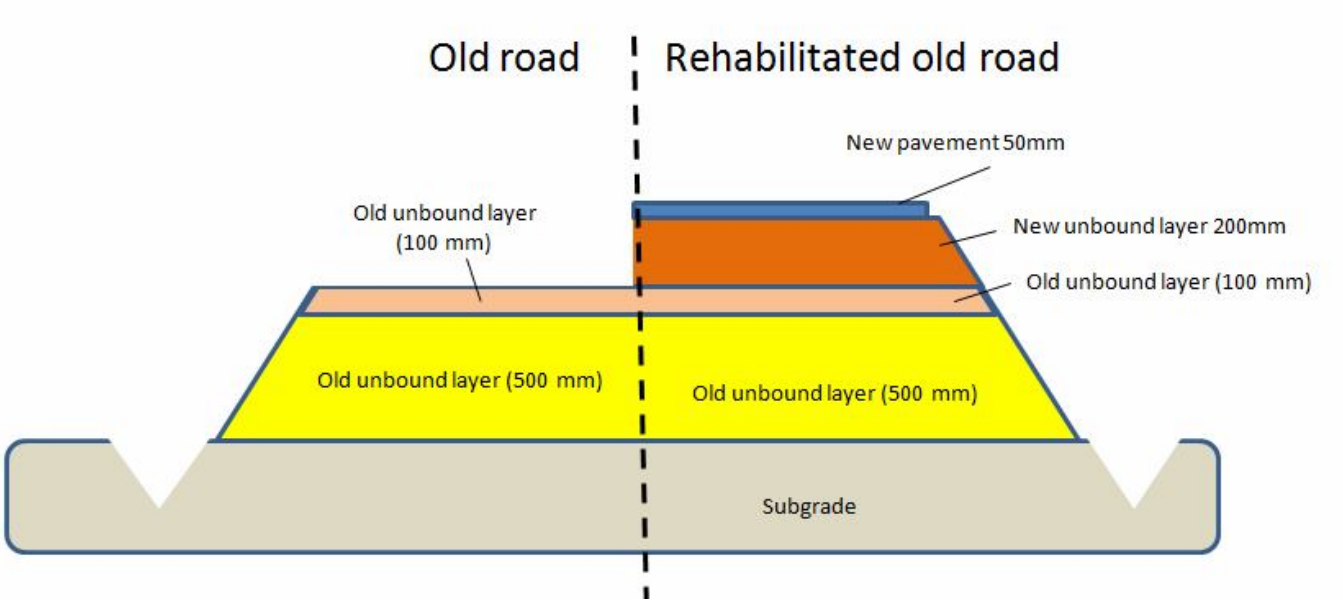
Structural Solutions

•Rehabilitation as gravel road



•Rehabilitation as paved road



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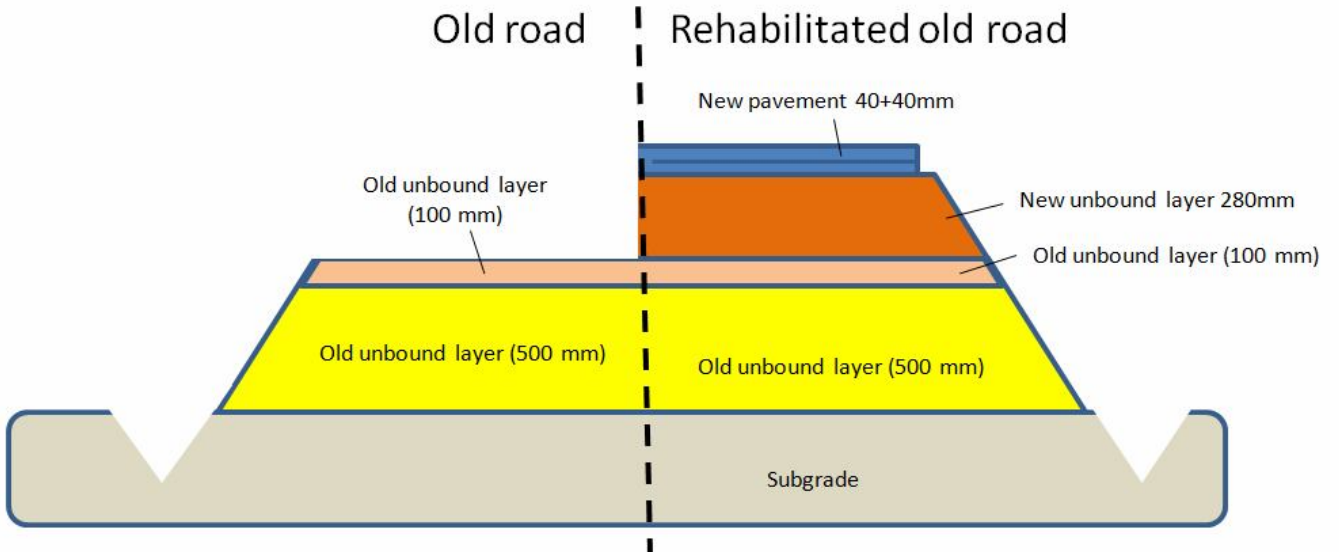
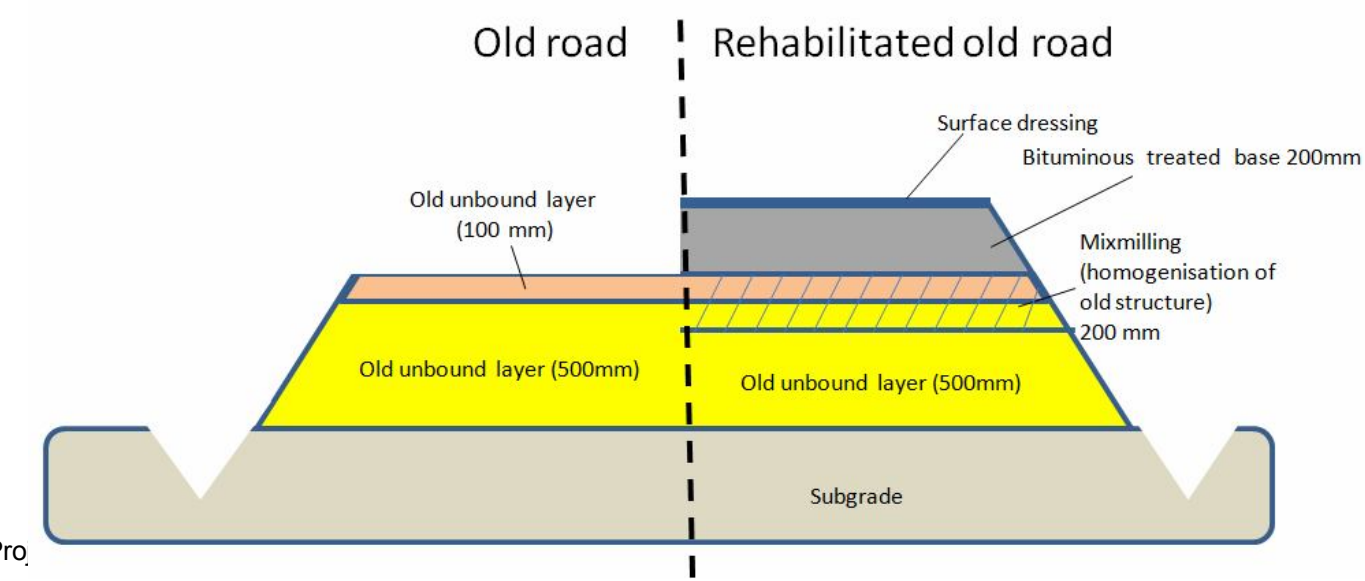
Structural Solutions

•Rehabilitation as 28cm (base) + 4+4cm (pavement) - structure



•Rehabilitation with bituminous treatment



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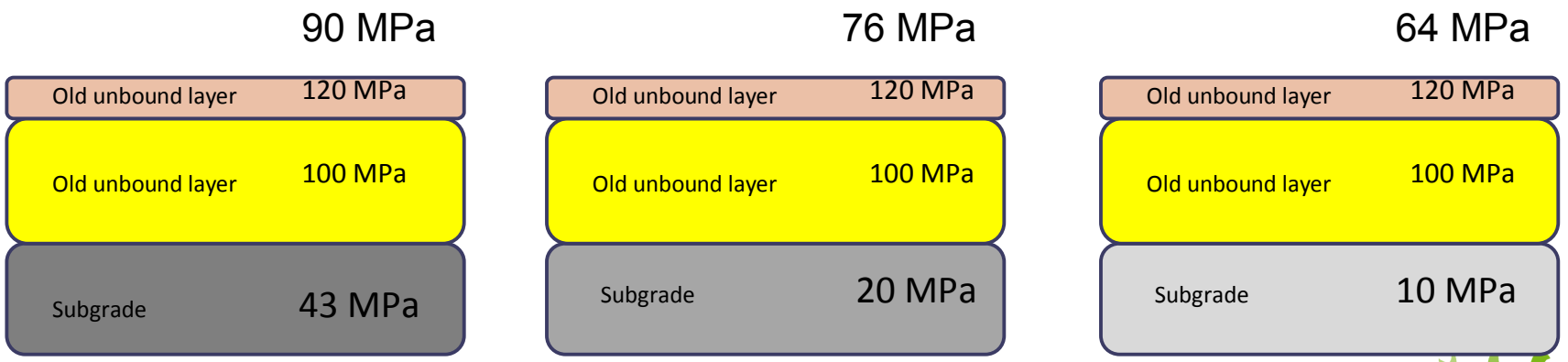
Odemark Bearing Capacity Calculations

The Odemark bearing capacity and stress & strain calculations were performed with three different subgrade moduli values

- 43 MPa (picked from source information)
- 20 MPa (represents weak subgrade, like silt, clay or moraine with high fines content)
- 10MPa (represents extremely weak subgrade, like silt, during spring thaw weakening period)

Odemark bearing capacity of initial structure



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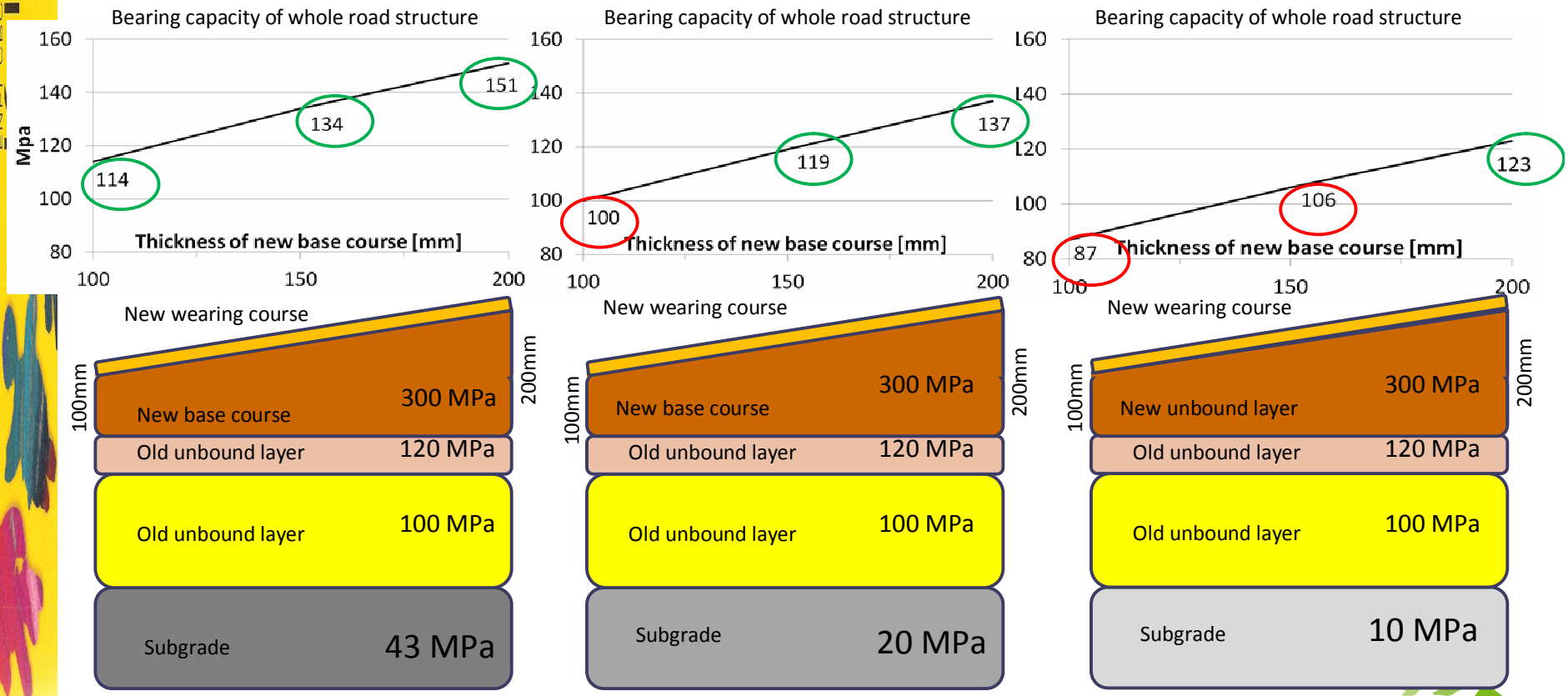
Odemark Bearing Capacity Calculations -Rehabilitated as gravel road

Target bearing capacity 110 MPa



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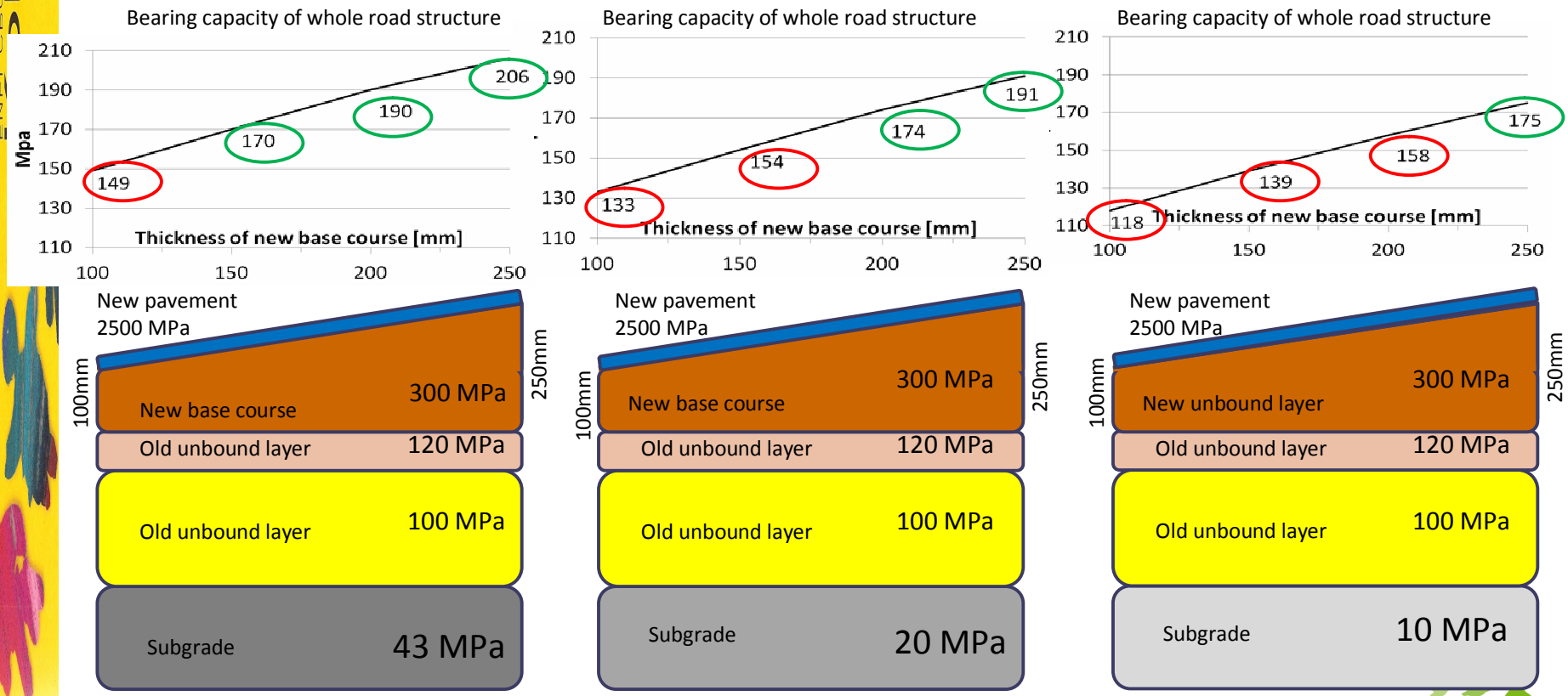
Odemark Bearing Capacity Calculations -Rehabilitated as paved road

Target bearing capacity 160 MPa



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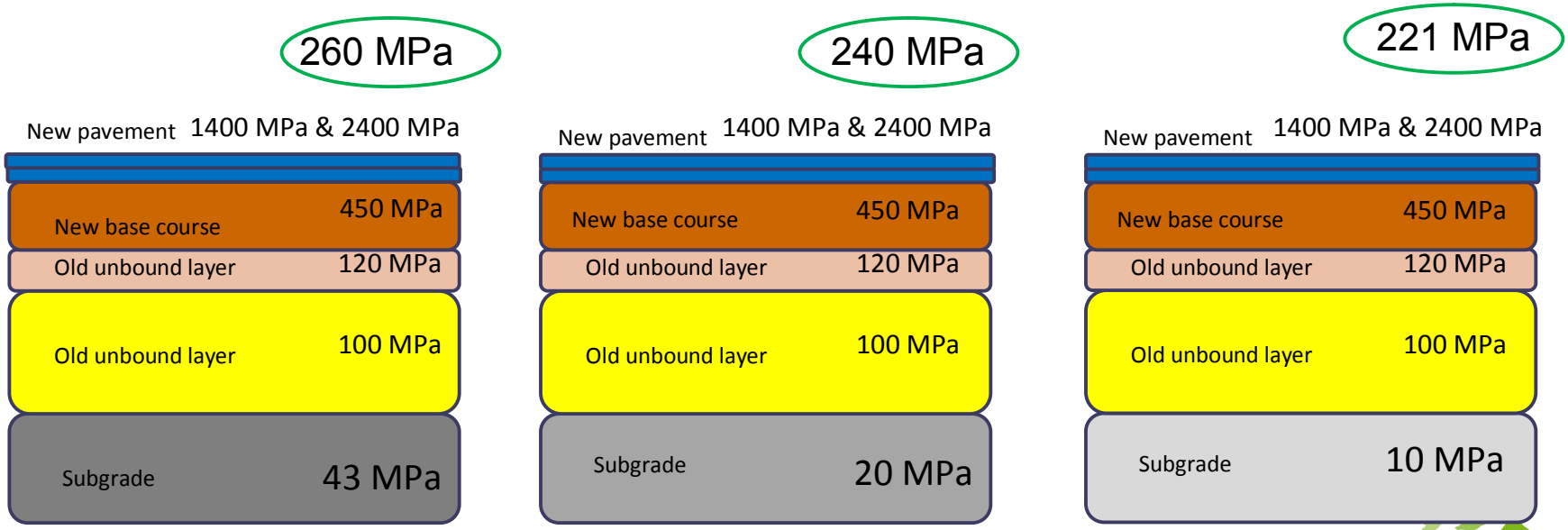
Odemark Bearing Capacity Calculations -Rehabilitated as paved road

Target bearing capacity 160 MPa

1400 MPa + 2400 MPa

Problems with base course and pavement compaction?



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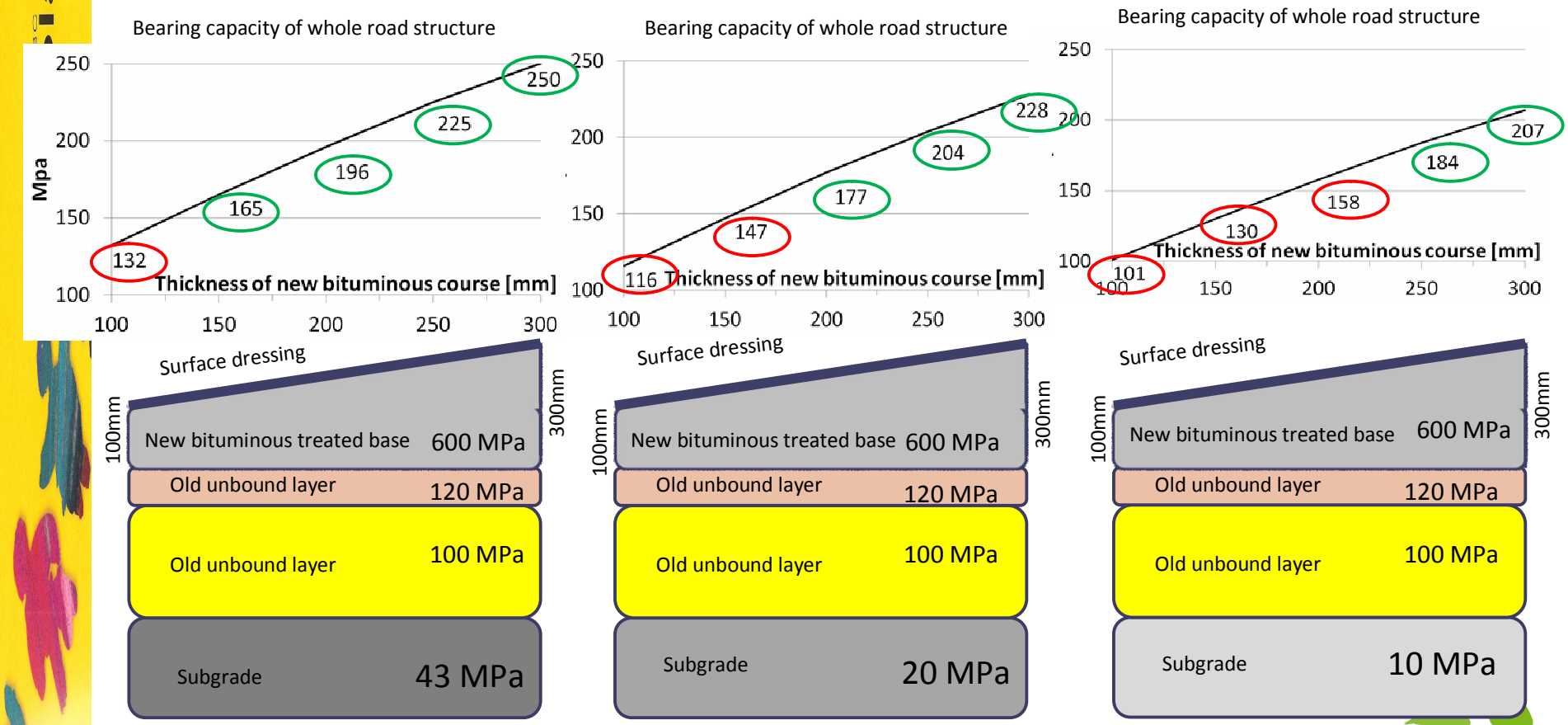
Odemark Bearing Capacity Calculations -Rehabilitated as bituminous treated base+ surface dressing

Target bearing capacity 160 MPa

Benefit: The use of local material!



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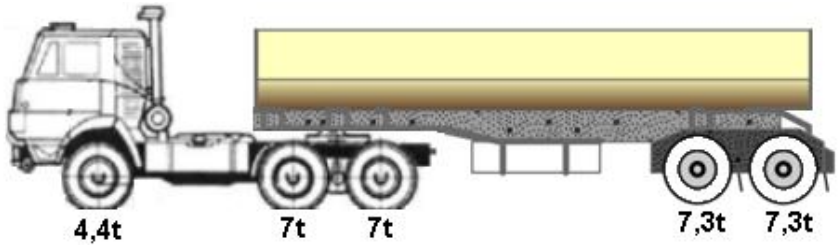
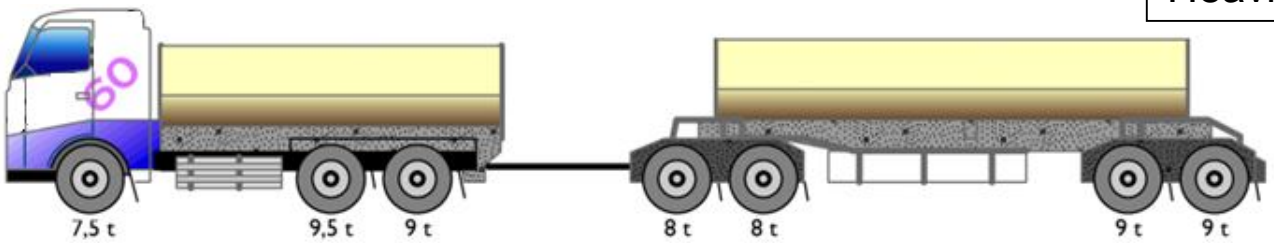
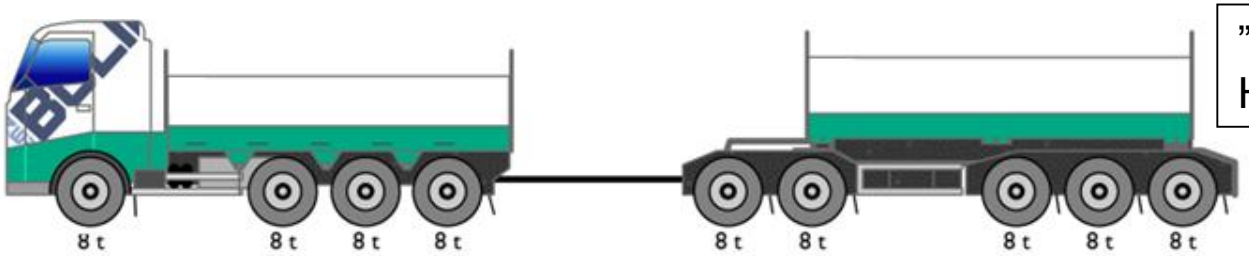
Calculated Truck Options



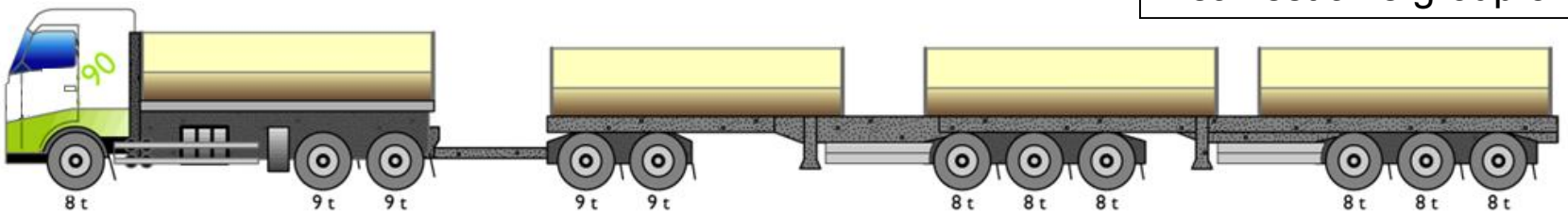
KAMAZ 33t
Heaviest axle group 2 x 7,3t



Standard 60t
Heaviest axle group 9t + 9,5t



”Boliden” 72t
Heaviest axle group 3 x 8t



”En trave till” 90t
Heaviest axle group 3 x 8t

Strains and Displacement Calculations With Different Trucks and Structures

Can be used on low traffic volume roads (< 500 vehicles/day).

Green means a safe stress and strain level and a very low risk for failure / permanent deformation.

Yellow means a moderate stress and strain level and a modest risk for failure / permanent deformation.

Red means a high stress and strain level and a high risk for failure / permanent deformation.

Black means that failure / rapid permanent deformation is likely to take place.

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Strains and Displacements Different Trucks and Structures

(subgrade modulus 43 MPa)

Truck / measuring axel group	Structure	Max. bound pavement horizontal strain	Max. unbound structure vertical strain	Max. subgrade vertical strain	Max. subgrade displacement
KAMAZ 33t / 2 x 7,3t	original structure		-3067	-652	947
Standard 60t / 9,5t + 9t	original structure		-4525	-901	1230
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure		-4552	-763	1377
KAMAZ 33t / 2 x 7,3t	original structure + 200mm base		-1110	-383	800
Standard 60t / 9,5t + 9t	original structure + 200mm base		-1700	-515	1028
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm base		-1726	-458	1201
KAMAZ 33t / 2 x 7,3t	original structure + 200mm base + 50mm pavement	242	-1010	-306	725
Standard 60t / 9,5t + 9t	original structure + 200mm base + 50mm pavement	370	-1466	-408	929
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm base + 50mm pavement	365	-1385	-378	1105
KAMAZ 33t / 2 x 7,3t	original structure + 280mm base + 80mm pavement	184	-603	-237	668
Standard 60t / 9,5t + 9t	original structure + 280mm base + 80mm pavement	276	-867	-312	854
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 280mm base + 80mm pavement	264	-806	-306	1034
KAMAZ 33t / 2 x 7,3t	original structure + 200mm bituminous treated base	318	-773	-352	773
Standard 60t / 9,5t + 9t	original structure + 200mm bituminous treated base	448	-1075	-471	992
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm bituminous treated base	376	-926	-425	1166

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Strains and Displacements Different Trucks and Structures

(subgrade modulus 20 MPa)

Truck / measuring axel group	Structure	Max. bound pavement horizontal strain	Max. unbound structure vertical strain	Max. subgrade vertical strain	Max. subgrade displacement
KAMAZ 33t / 2 x 7,3t	original structure		-3006	-1044	1875
Standard 60t / 9,5t + 9t	original structure		-4425	-1429	2416
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure		-4465	-1247	2780
KAMAZ 33t / 2 x 7,3t	original structure + 200mm base		-1074	-628	1559
Standard 60t / 9,5t + 9t	original structure + 200mm base		-1653	-835	1998
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm base		-1679	-785	2390
KAMAZ 33t / 2 x 7,3t	original structure + 200mm base + 50mm pavement	230	-998	-502	1390
Standard 60t / 9,5t + 9t	original structure + 200mm base + 50mm pavement	354	-1450	-661	1778
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm base + 50mm pavement	350	-1368	-650	2160
KAMAZ 33t / 2 x 7,3t	original structure + 280mm base + 80mm pavement	175	-593	-394	1270
Standard 60t / 9,5t + 9t	original structure + 280mm base + 80mm pavement	264	-854	-513	1623
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 280mm base + 80mm pavement	251	-792	-535	2000
KAMAZ 33t / 2 x 7,3t	original structure + 200mm bituminous treated base	316	-766	-579	1498
Standard 60t / 9,5t + 9t	original structure + 200mm bituminous treated base	446	-1066	-767	1918
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm bituminous treated base	372	-917	-732	2306

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Strains and Displacements Different Trucks and Structures

(subgrade modulus 10 MPa)

Truck / measuring axel group	Structure	Max. bound pavement horizontal strain	Max. unbound structure vertical strain	Max. subgrade vertical strain	Max. subgrade displacement
KAMAZ 33t / 2 x 7,3t	original structure		-2933	-1534	3440
Standard 60t / 9,5t + 9t	original structure		-4307	-2073	4412
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure		-4352	-1894	5205
KAMAZ 33t / 2 x 7,3t	original structure + 200mm base		-1030	-939	2799
Standard 60t / 9,5t + 9t	original structure + 200mm base		-1598	-1236	3579
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm base		-1619	-1230	4366
KAMAZ 33t / 2 x 7,3t	original structure + 200mm base + 50mm pavement	216	-984	-743	2449
Standard 60t / 9,5t + 9t	original structure + 200mm base + 50mm pavement	336	-1432	-971	3131
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm base + 50mm pavement	330	-1347	-1007	3870
KAMAZ 33t / 2 x 7,3t	original structure + 280mm base + 80mm pavement	164	-582	-593	2222
Standard 60t / 9,5t + 9t	original structure + 280mm base + 80mm pavement	250	-840	-765	2839
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 280mm base + 80mm pavement	235	-776	-837	3547
KAMAZ 33t / 2 x 7,3t	original structure + 200mm bituminous treated base	315	-760	-865	2673
Standard 60t / 9,5t + 9t	original structure + 200mm bituminous treated base	444	-1058	-1135	3417
"Boliden" 72t & "En trave till" 90t / 3 x 8t	original structure + 200mm bituminous treated base	369	-909	-1147	4188

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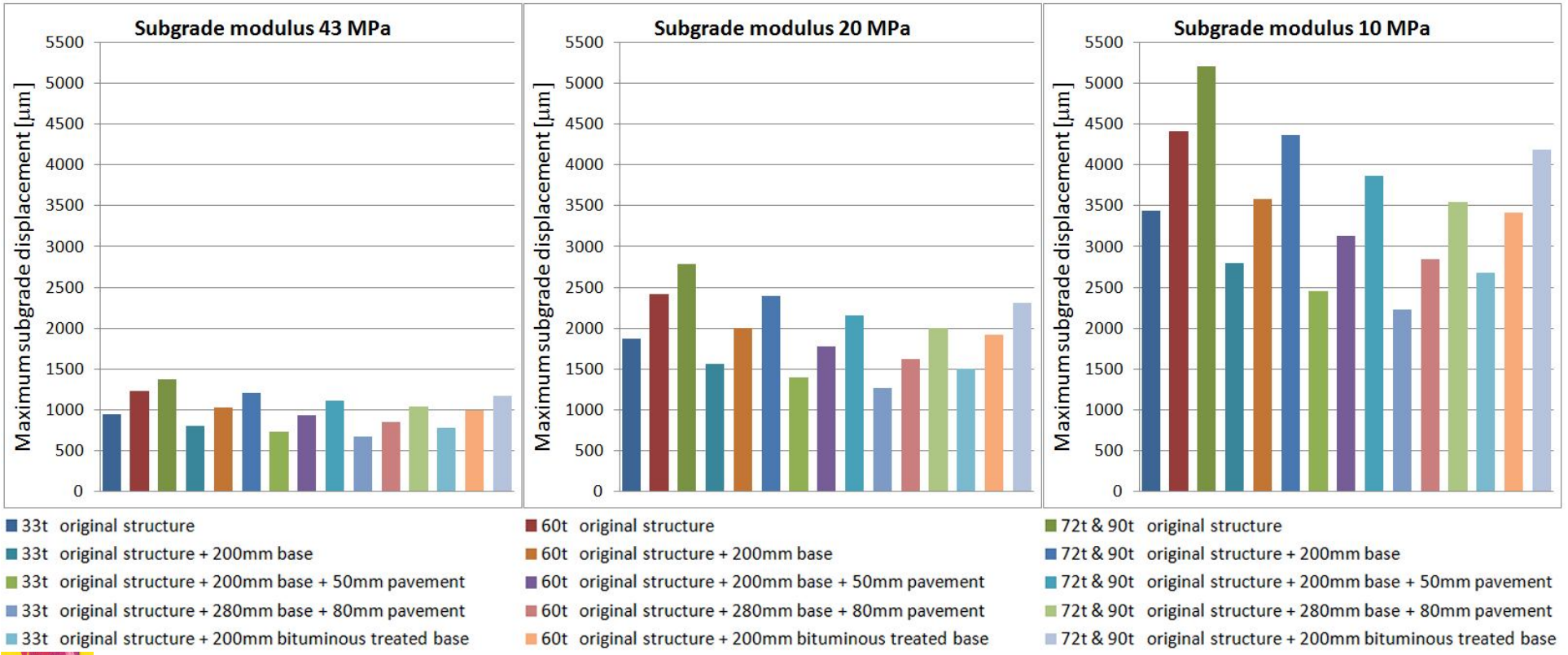
Subgrade Displacement



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Background Facts for Rehabilitation Design

• Gravel and hard rock aggregates missing in the area (closest sources are in Karelia) → Long transport distances → high costs for new materials

→ treatment or stabilisation is good option

→ mixing ballast 8 – 32 mm into current base coudl be also an option (however not calculated in this work)

• The current material of road structures has quite high fines content and is sensitive for water and frost

• Road is too wide and has lack of proper crass fall - **Narrowing of the road and drainage improvement is vital!**

• Drainage is mainly missing **– good draiange design is also vital**

• Old structure should be homogenised before building new structures (mixmilling)

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Conlusions and recommendations

Best option:

- 200mm Bitumen treated base would be the most sustainable solution
  - •The local material can be used (bitumen content 2 %??)
  - •The adequate Odemark bearing capacity can be reached also on weak subgrade (10 MPa)
  - •Maximum horizontal strain on bound pavement and vertical strain on unbound structure are minor– however minor risk with subgrade strain in spring
  - •The maximum subgrade displacement is approximately on the same level than with the ROADEX paved structure (200 mm base + 50 mm pavement)
  - • This structure would allow also the use of heavier truck options

Also good option but migh be much more expensive:

- 280mm unbound base + 40 + 40 bituminous layers

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