NTNU – Trondheim
Norwegian University of
Science and Technology

Frost Protection for Roads and Railways

Røros test site: 1 year of data

NADim-seminar
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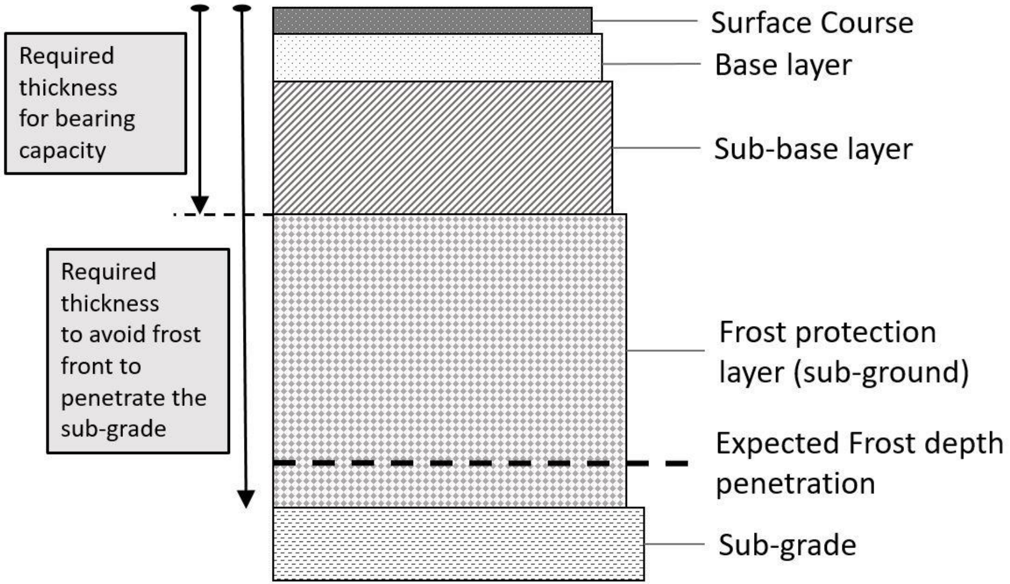
Outline

- Introduction
- Frost Protection Layer Standard
- Røros experimental test site
- Results and discussion
- Conclusion

Introduction

- Frost Protection Project (2016-2019)
  - Frost heave problems (winters 2010 and 2011)
    - Crushed rock material vs natural gravel?
    - Segregation of the material?

Frost Protection Layer



Modified from Aksnes presentation, 2016.

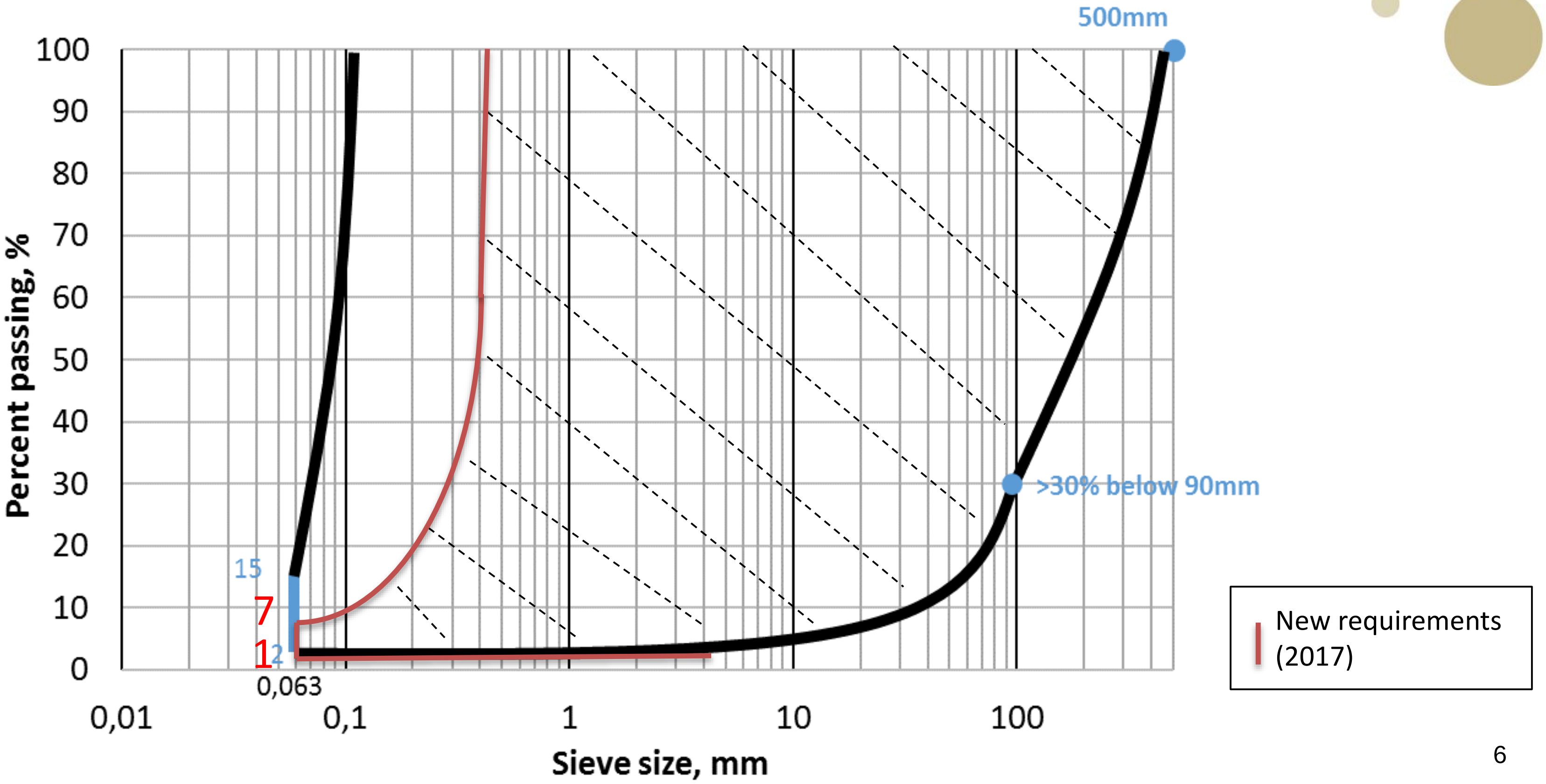
- Prevent frost to penetrate in natural soil
- Maximum thickness of road: 1,8 m to 2,4 m

Frost Protection Layer

- Material must be crushed in a controlled production.
- Materials up to half the thickness of the layer (never >500 mm).
- Material less than 90mm shall be at least 30%.
- Fines less than 0,063mm shall be 1-7% calculated from 90 mm.
- Grading uniformity coefficient Cu> = 5 (well graded).

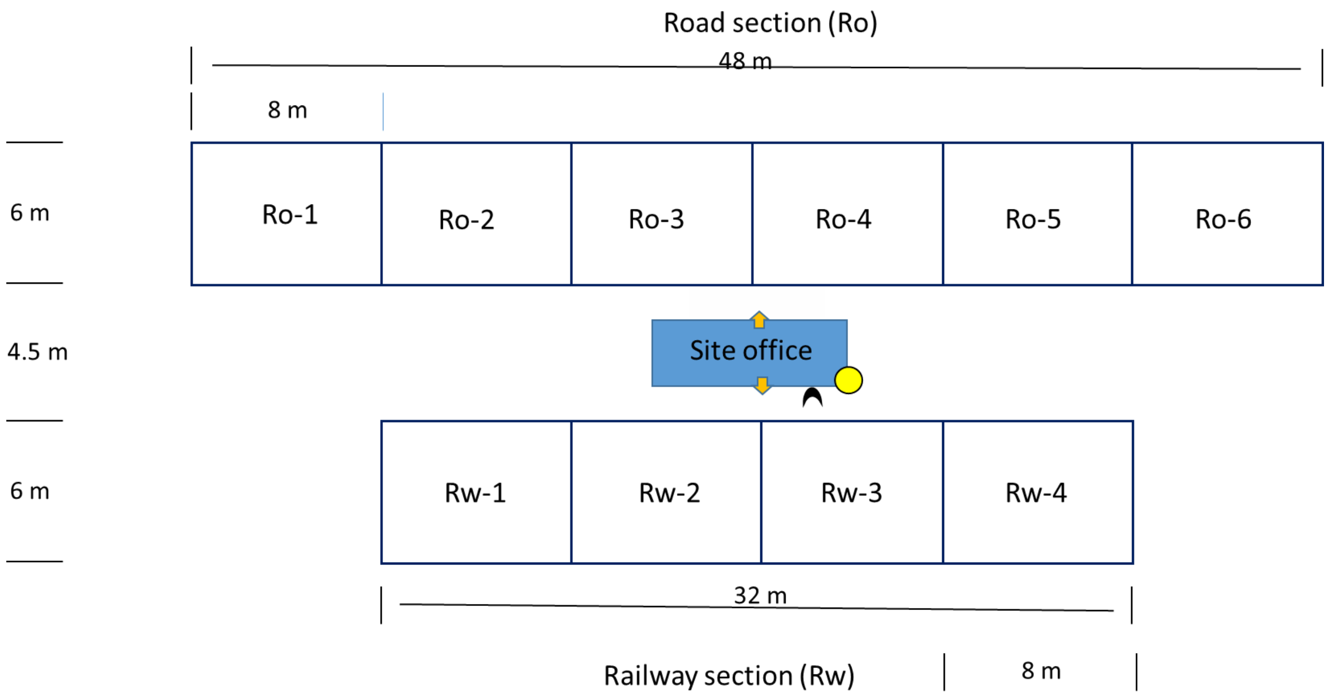
(from revised 2017 N200 design book)

Frost Protection Layer

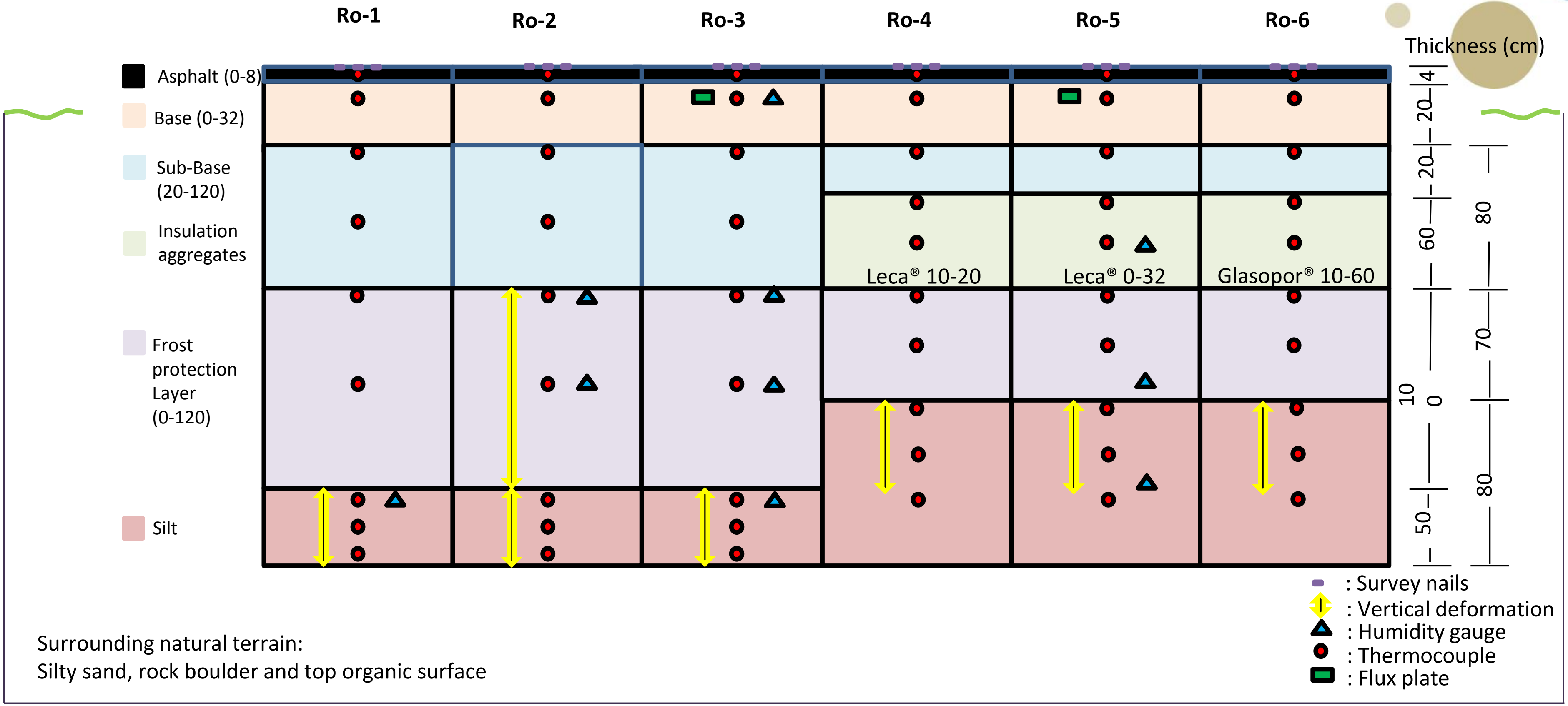


Roros Test site

Roros Test site



Road sections

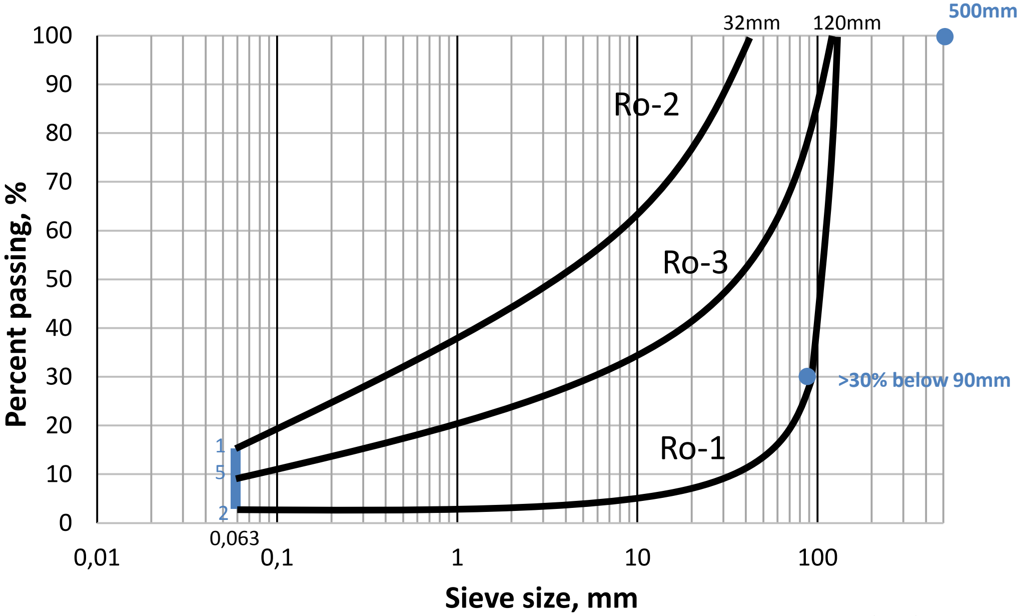


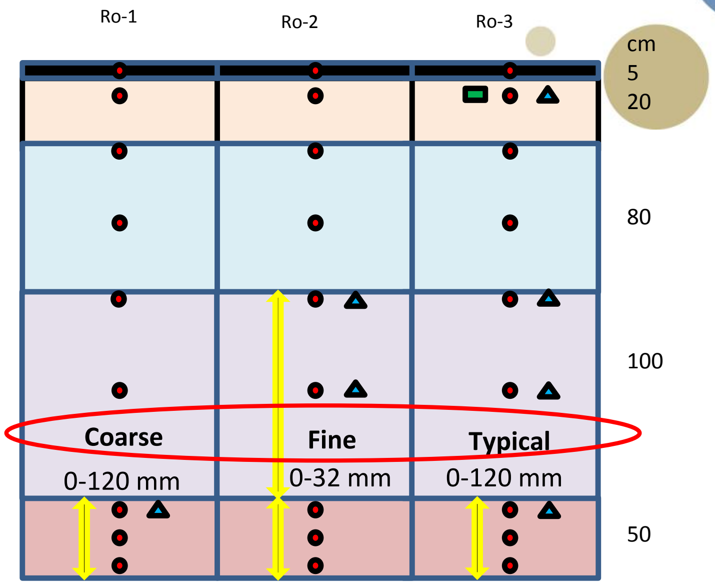
Surrounding natural terrain:
Silty sand, rock boulder and top organic surface

Variation of grading curves: Road Sections Ro-1 – Ro-3

- 3 differents grading in frost protection layers

i.	Ro-1: 0-120 mm,	'Coarse'
ii.	Ro-2: 0-32 mm,	'Fine'
iii.	Ro-3: 0-120	'Typical'



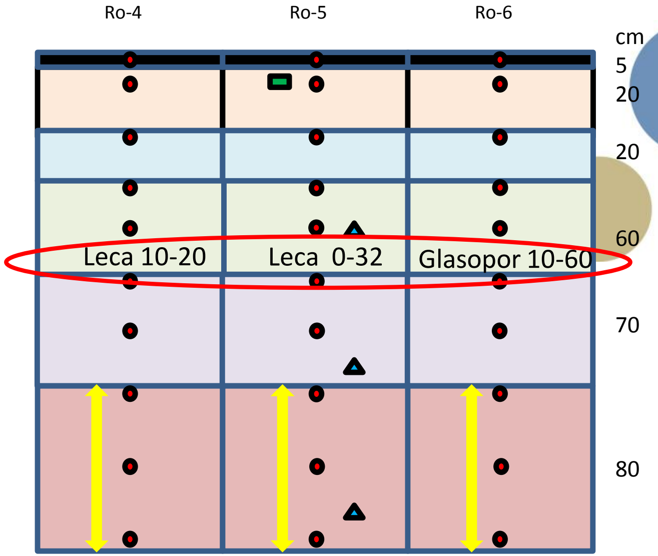


From: Karlis Rieksts 2016

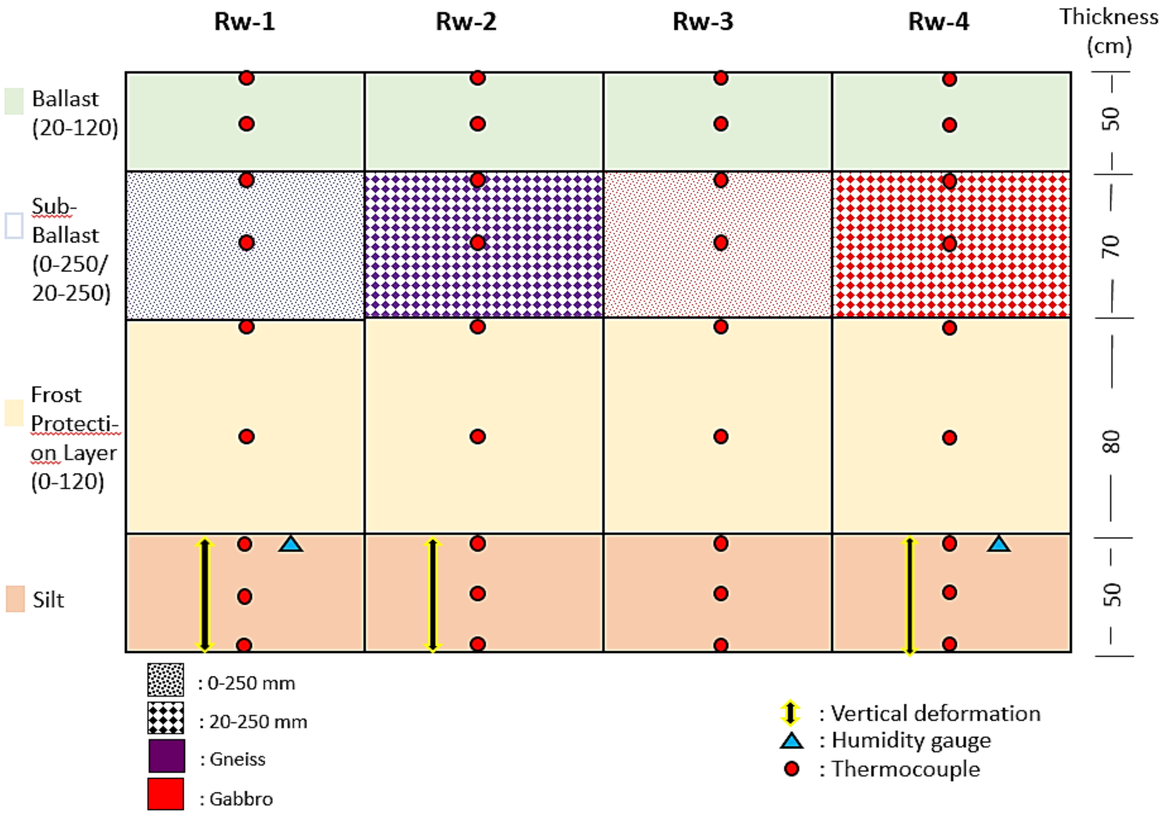
Ro-1:	0-120 mm,	'Coarse'
Ro-2:	0-32 mm,	'Fine'
Ro-3:	0-120	'Typical'

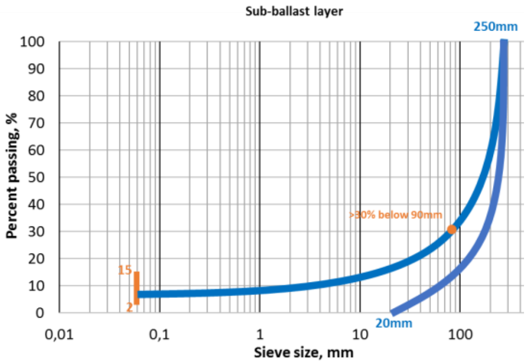
Variation of insulation material: Road Section Ro4 –Ro6

- 2 products: Expanded clay pebbles and Foam Glass
  - Expanded clay from Leca®
    - 0-32 mm in Ro-4
    - 10-20 mm in Ro-5
  - Foam Glass from Glasopor®
    - 10-60 mm in Ro-6



Røros test site, side view: Railway section



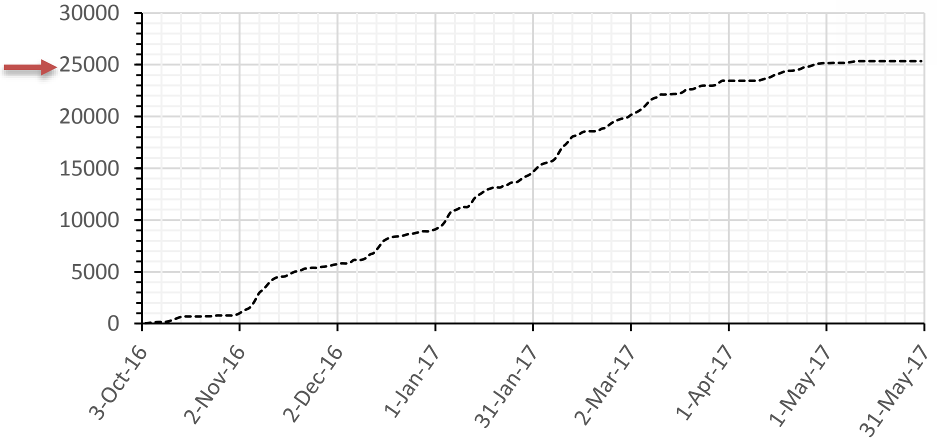



Quartzite
Gabbro

1 year of data

- CLIMATIC DATA

FI (h°C) evolution vs time in Røros 2016-2017



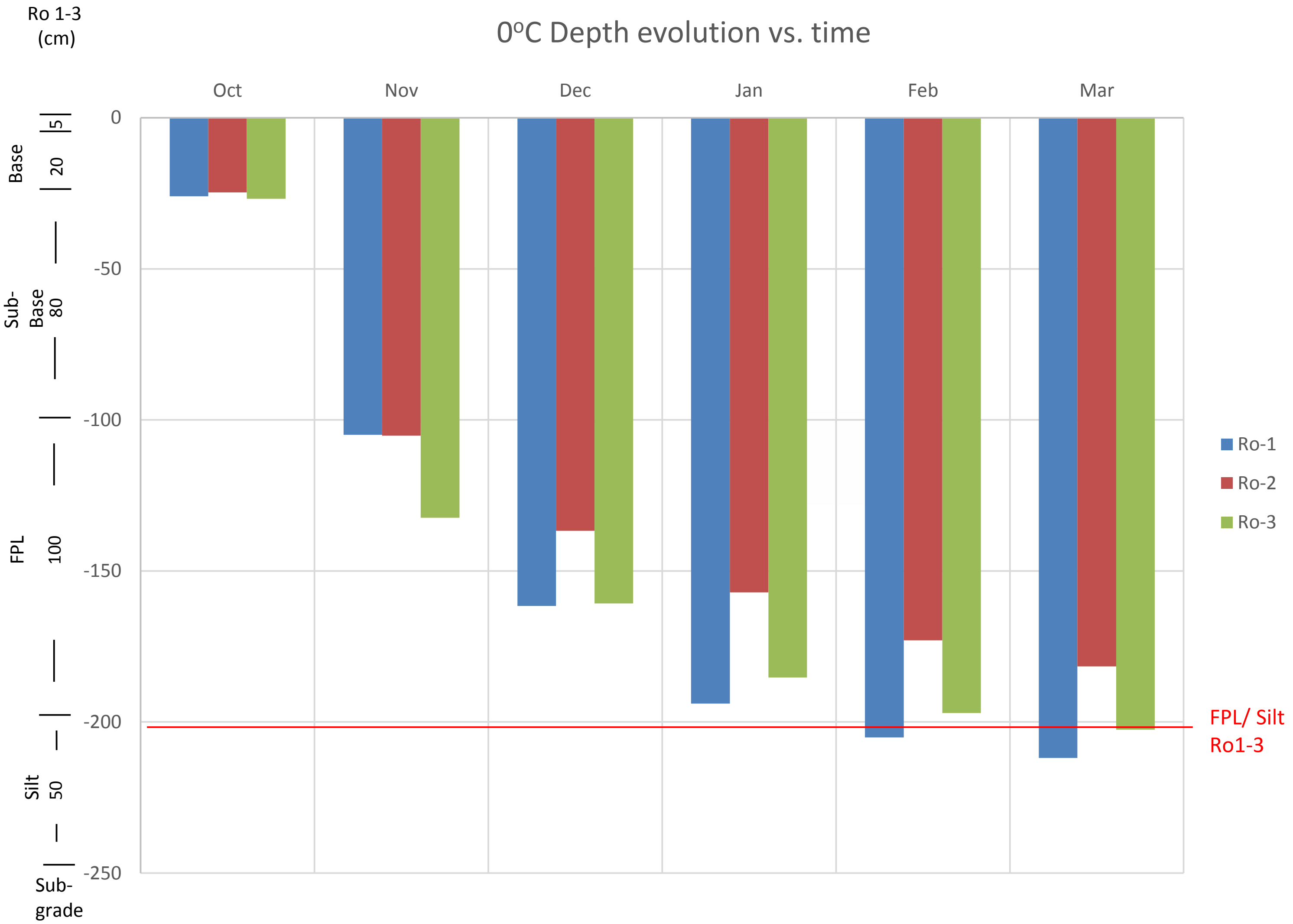
- FI: MAT (F2, F10 and F100)
  - Røros: 0,2°C; 21k; 39k; 61k;
  - Trondheim: 5,3°C; 4k; 11k; 19k;
  - Oslo: 6,4°C; 5k; 12k; 21k;
  - Bergen: 7,6°C; 1k; 2k; 4k;

- Winter 2016-2017 at Røros
  FI ≈ 25 000
  MAT = 1,3°C

1 year of data

- Frost penetration depth
  - Does FPL is actually giving expected results?
  - Grading, insulation and mineralogy effects
- Looking to FDP evolution at the end of each month

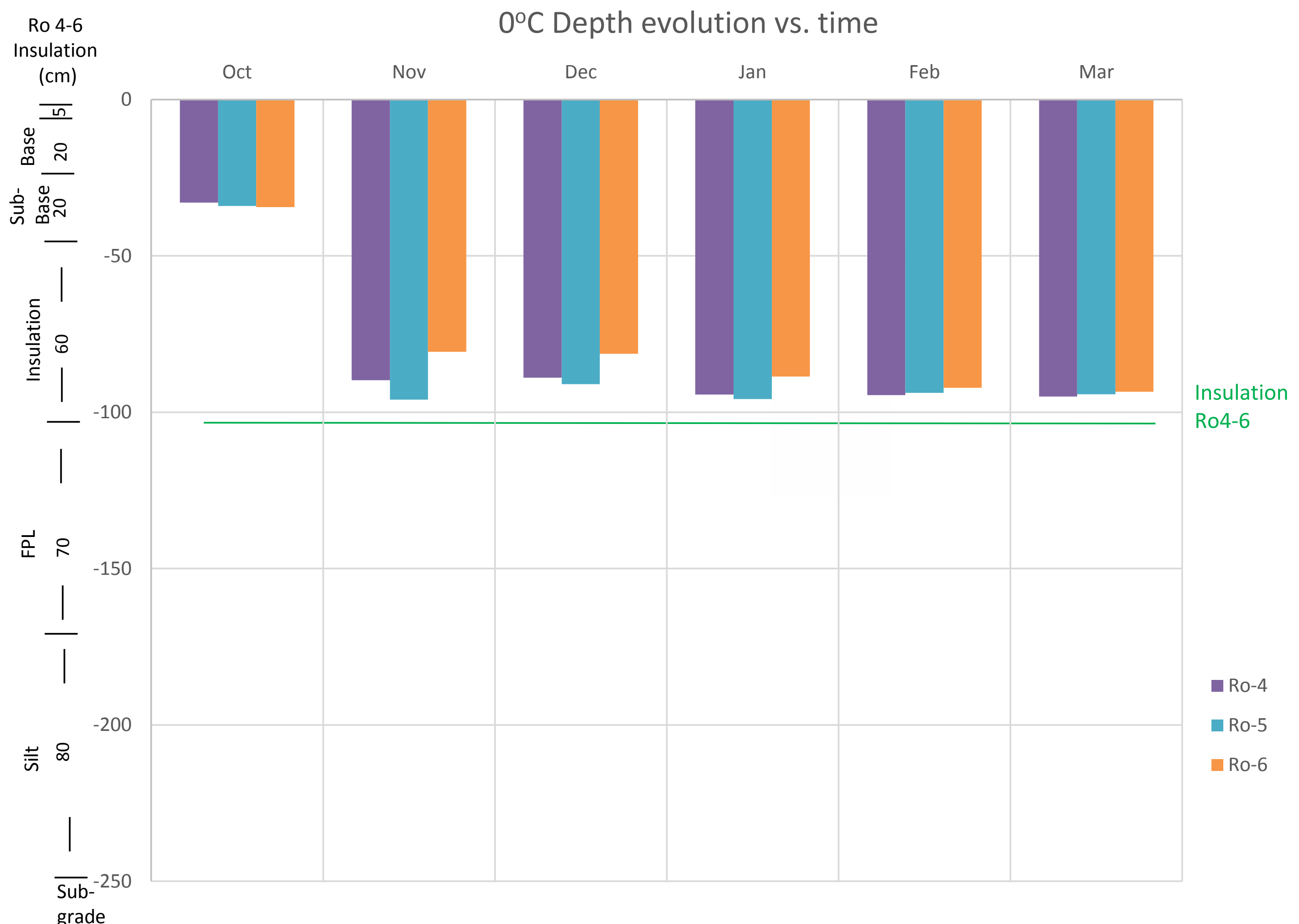
Ro-1 to Ro-3



Vary FPL Grading
Ro-1: Coarse
Ro-2: Fine
Ro-3: Typical

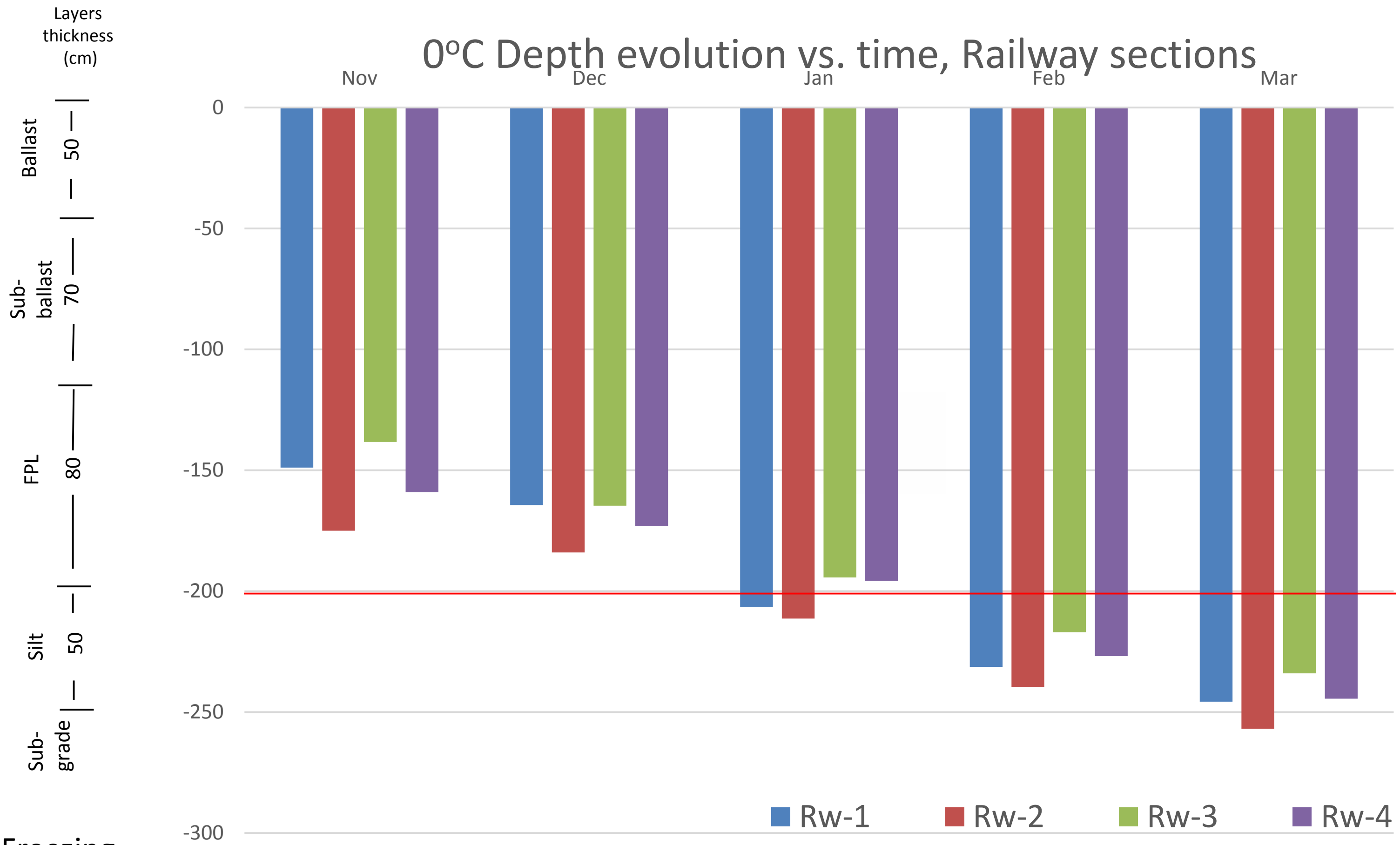
Freezing Index: 25000

Ro-4 to Ro-6



Vary FPL insulation agg.
Ro-4: Leca® 10-20
Ro-5: Leca® 0-32
Ro-6: Glasopor ® 10-60

Freezing Index: 25000



Freezing Index: 25000

Varying sub-ballast grading & mineralogy:

Rw-1: 0-250 mm, Quartzite;

Rw-2: 20-250 mm, Quartzite;

Rw-3: 0-250 mm, Gabbro;

Rw-4: 20-250 mm, Gabbro;

EXPECTED VS OBSERVED

Comparing necessary FI contribution to completely go through the FPL

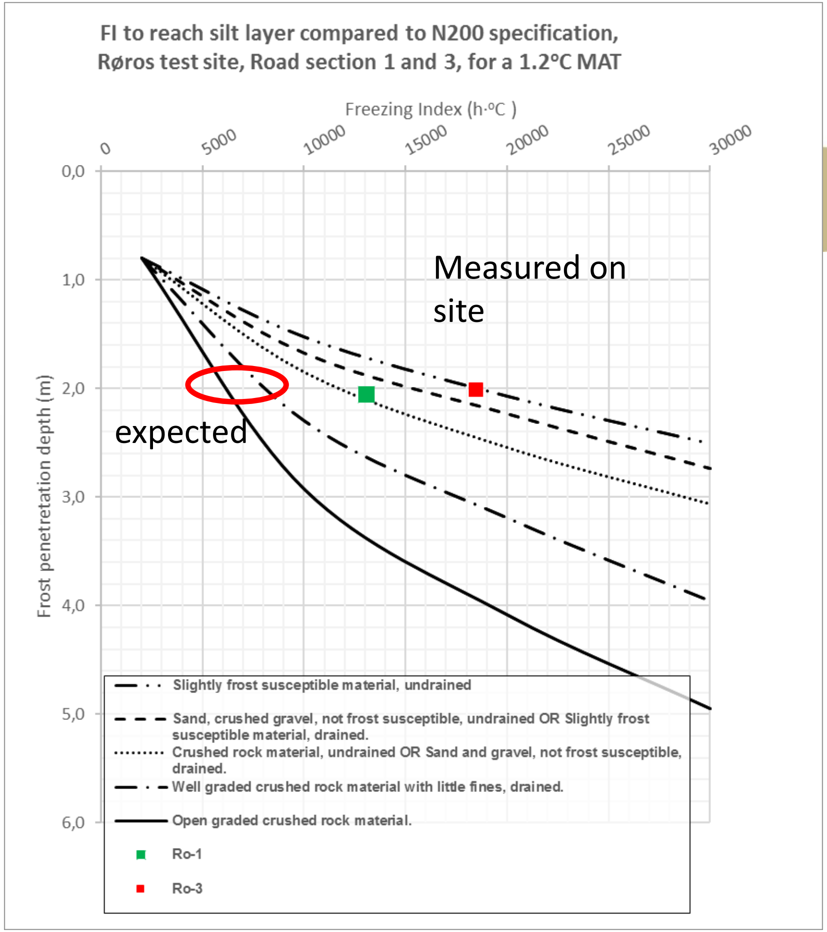
Silt layer in sections are at 2,05m

FI necessary to reach the silt layer (°C·h)

Ro-1: 13000
Ro-2: N/A
Ro-3: 18500

Frost penetration depth calculated to reach 2 m:

FI: 9000



EXPECTED VS OBSERVED

Comparing necessary FI contribution to completely traverse the FPL

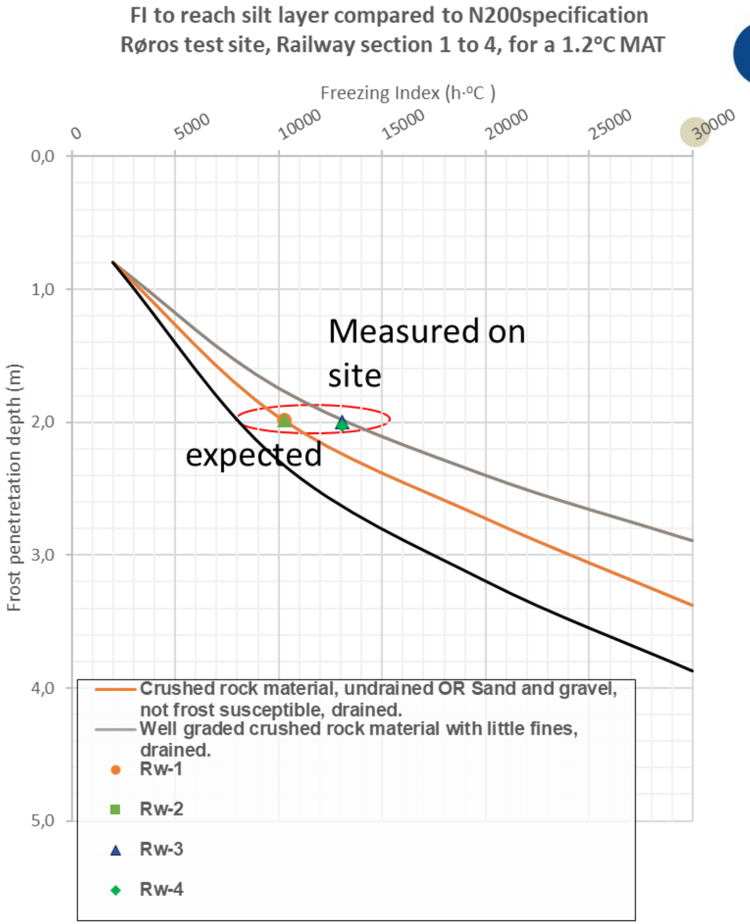
Silt layer in sections are at 2m

FI necessary to reach the silt layer (°C·h)

Rw-1: 10300
Rw-2:10300
Rw-3: 13000
Rw-4: 12900

Frost penetration depth calculated to reach 2 m:

FI: 9000



1 year of data

- Does max thickness are enough
  - Can better knowledge lead to better design? ($, z)
- Does material thermal properties are maximized?
  - Water retention vs fine%
- Can cost production be optimized?
  - Less thick layers -> less construction cost

Conclusions

- The test site is a good tool for investigating the standard assessment
- Data concerning frost penetration according grading, mineralogy and insulation in each sections make sense according to known theories.
- Contributive FI to go through FPL in Road section are higher than what expected in N200. The variation seems to be caused by the presence of water at the bottom of the layer.
- Contributive FI to go through the railway structure sections correspond quite well to standard evaluation.

Conclusions

- All sections of roads and railways with typical or coarse grading frost protection layer failed to prevent frost penetration inside the silt layer even with the ‘help’ of water at the bottom of it.

- 0-32 FPL grading in Ro-2 and insulation material is preventing frost to reach the silt layer.

- Further development regarding design method is to be done.

Thanks to collaborators and partners

- The Research Council of Norway
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- Glasopor®
- SINTEF Byggforsk
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