



Business from technology

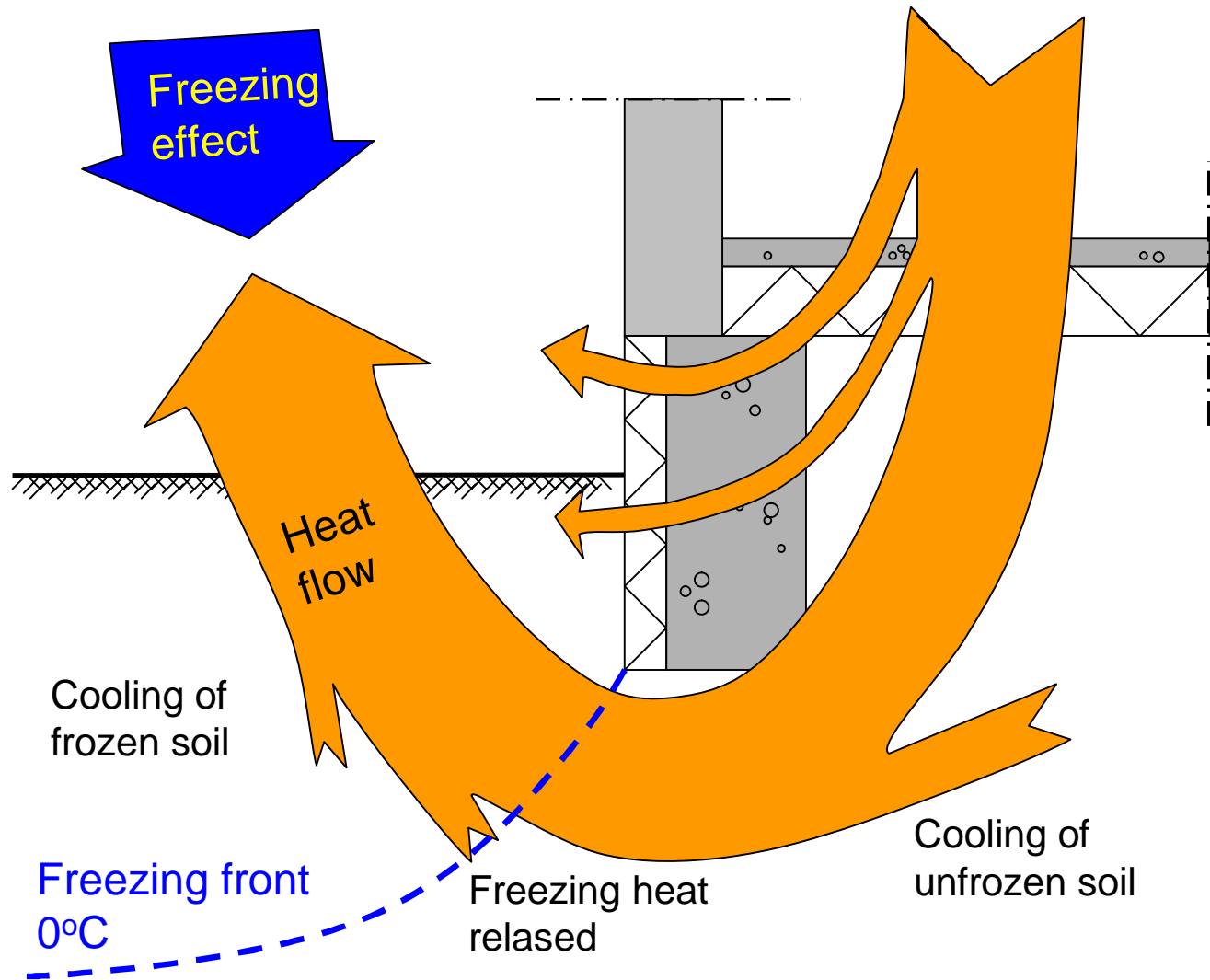
Frost insulation of the Finnish slab on ground foundation

NSB 2011, 9th Nordic Symposium on Building Physics

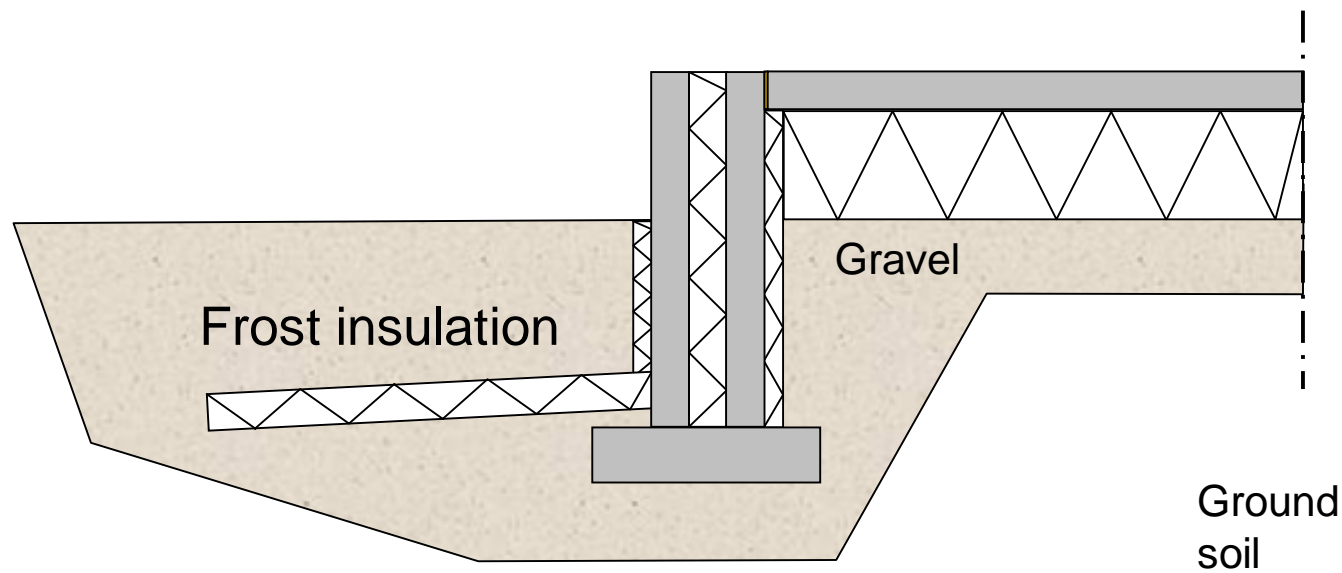
Miimu Airaksinen, Jorma Heikkinen
VTT Technical Research Centre of Finland

Contents

- Frost protection principle
- Need for the present research
- Numerical model
- Frost penetration along walls (2D)
- Frost penetration in corners (3D)
- Conclusion

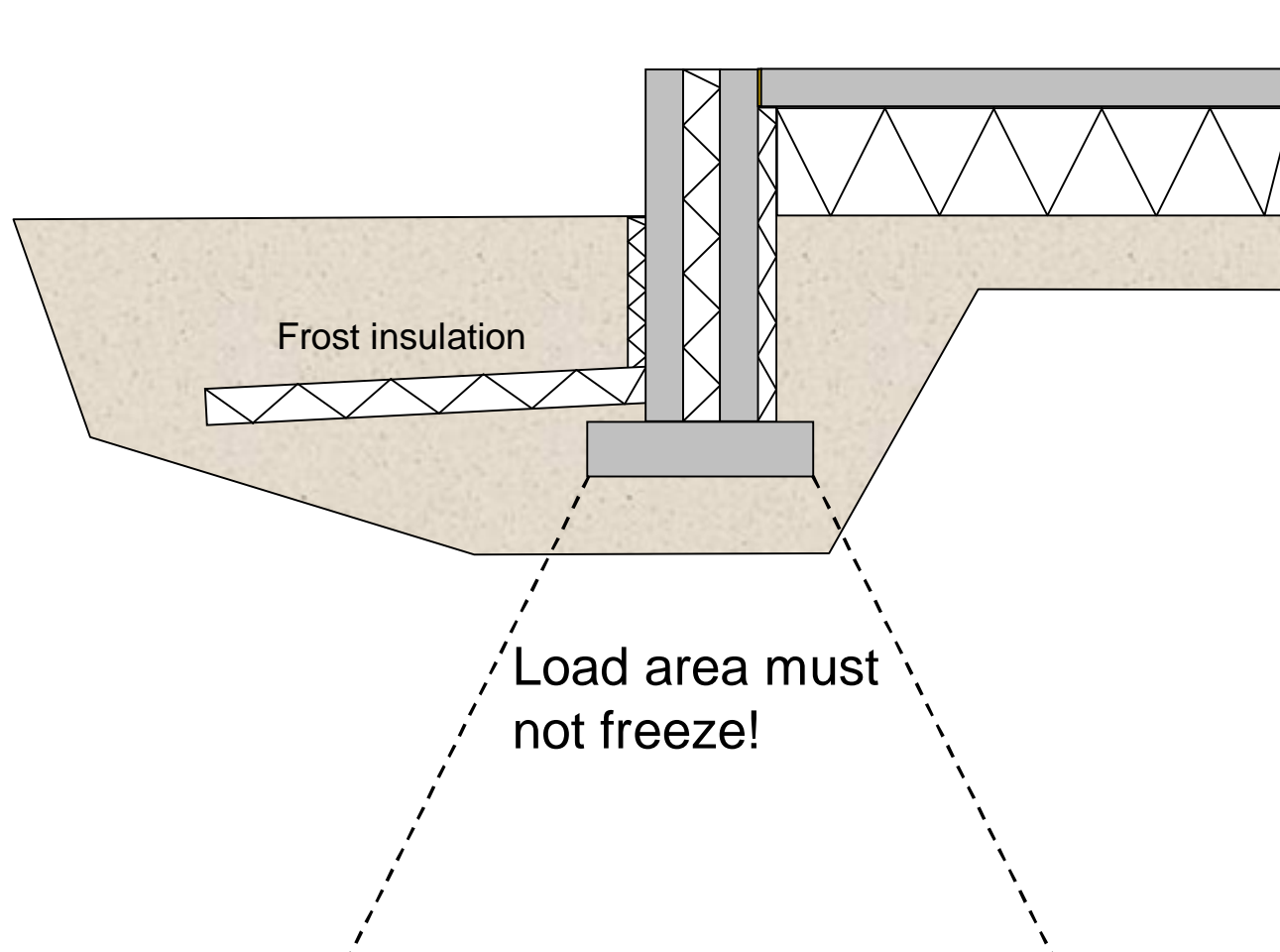


Typical frost insulation

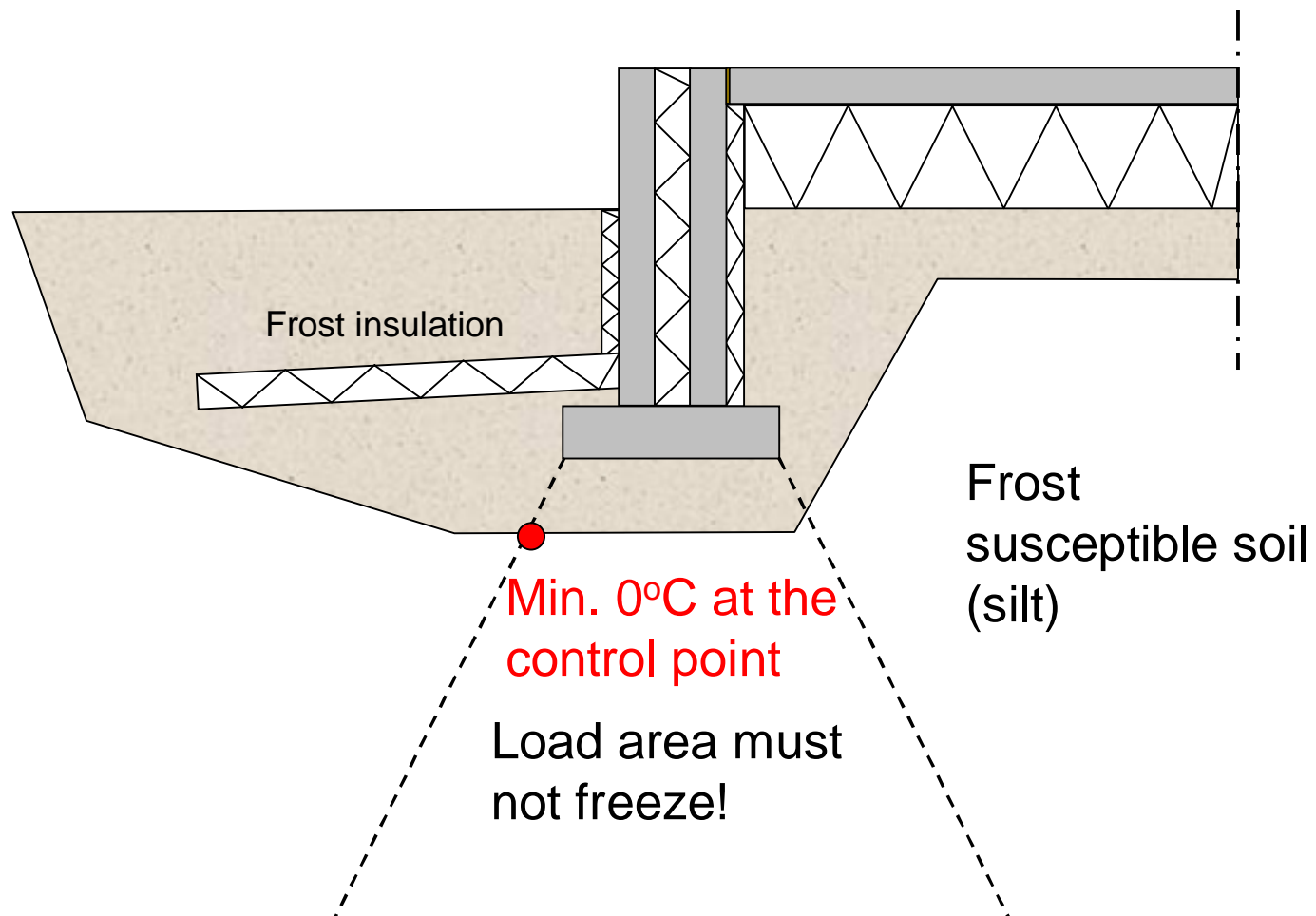


Frost insulation increases temperature under the foundation

Zone of stress influence



Frost criterion in Finland



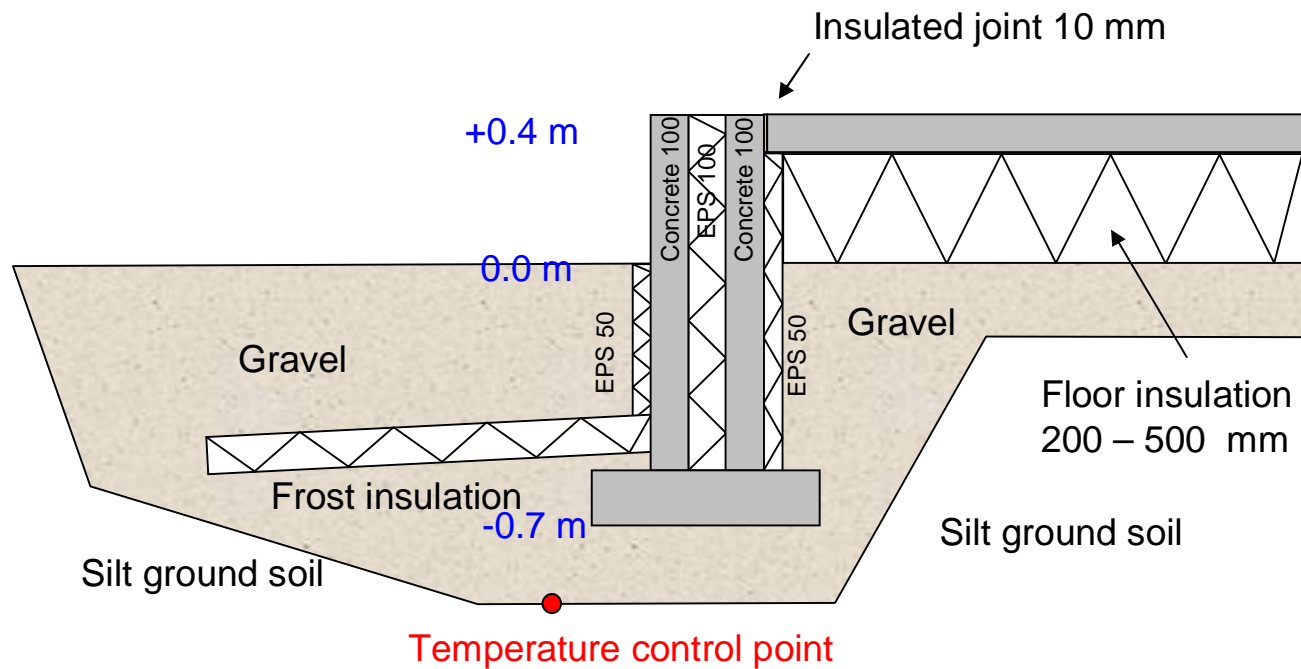
Standards and guidelines

- EN ISO 13793, 2001. Thermal performance of buildings. Thermal design of foundations to avoid frost heave
- Instructions for frost protection in building construction, 2007 (In Finnish).

Need for new frost simulations

- Need to cover the floor insulation thickness of today and future, up to 500 mm
 - Tables and figures in ISO-standard are for thickness about 180 mm maximum
 - Finnish guidelines: maximum thickness about 350 mm
- Present guidelines for corners are based on very old data (1970's)
- Finnish guidelines are based on foundation wall that is insulated all the way above the ground level – which is not always the case

Present simulations, non-insulated foundation wall



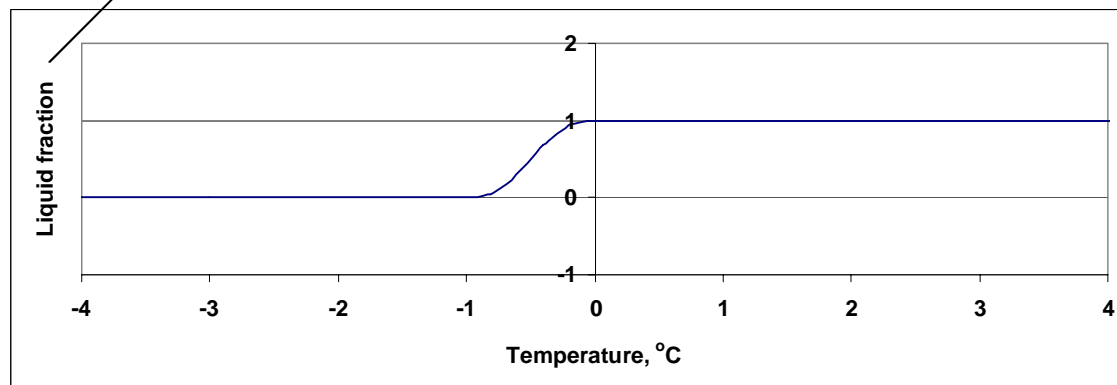
Numerical model

- Transient 2D and 3D heat conduction equation

$$\rho c \frac{\partial T}{\partial t} - \nabla \cdot (k \nabla T) = 0$$

- Phase change included in effective heat capacity

$$c = c_u LF + c_{fr} (1 - LF) + \frac{dLF}{dT} l \quad \leftarrow \text{Latent heat}$$

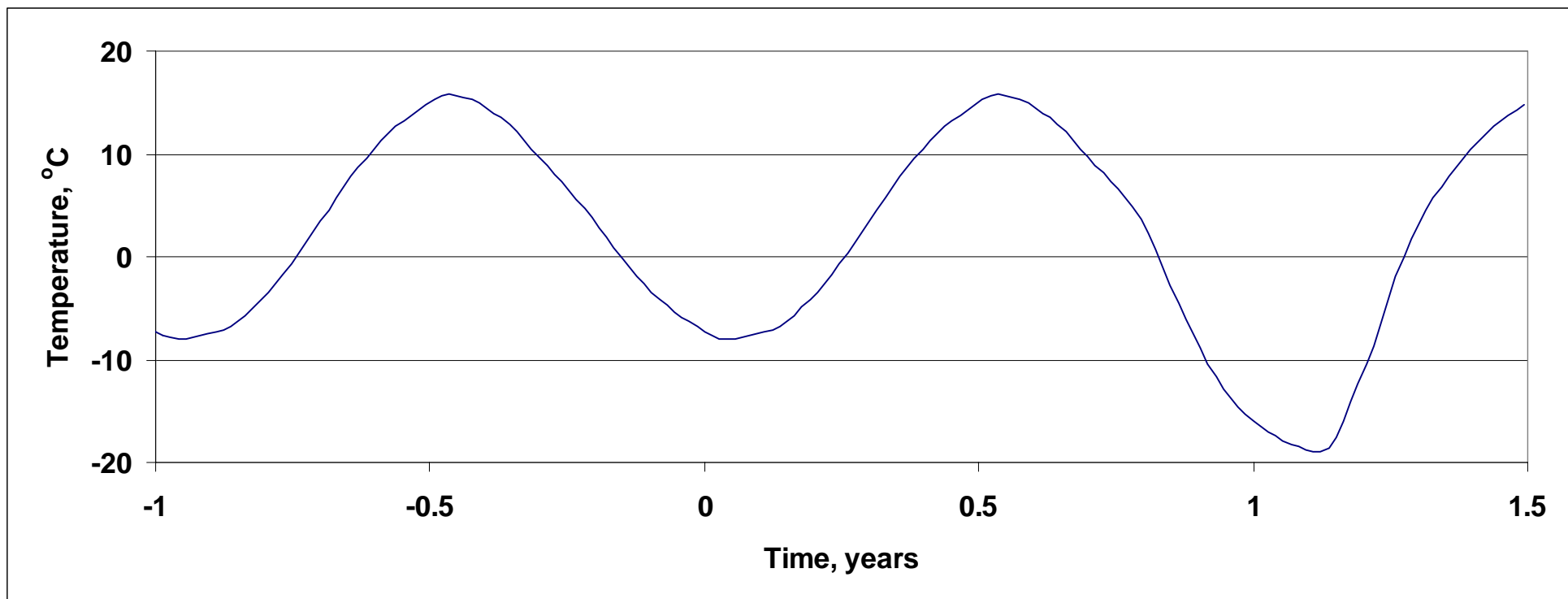


Implemented in
Comsol Multiphysics

Weather data for central Finland

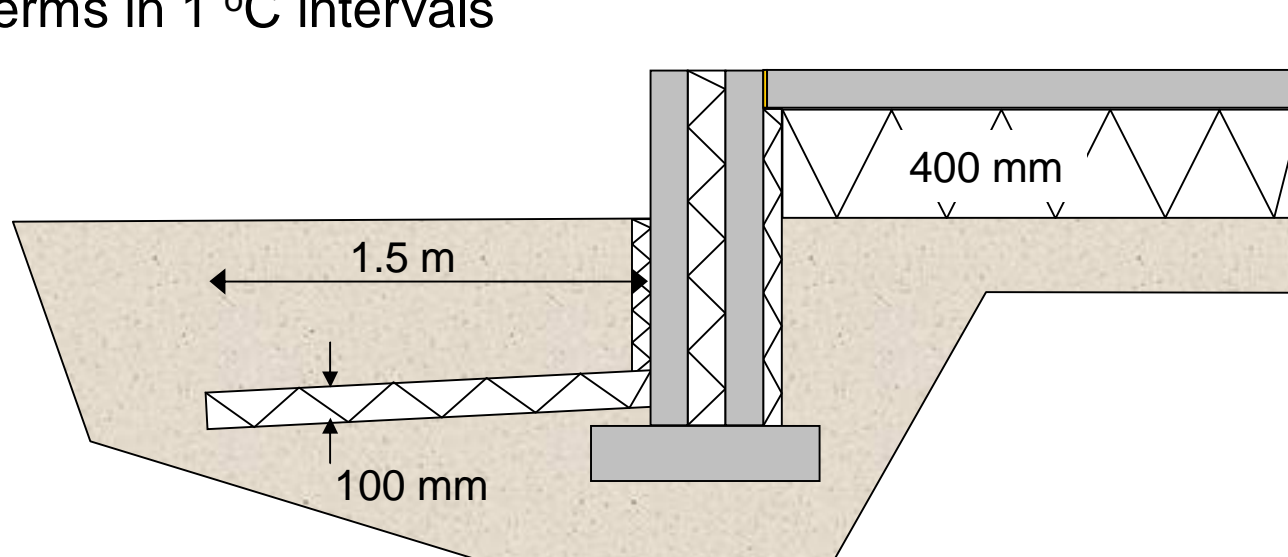
8 normal years

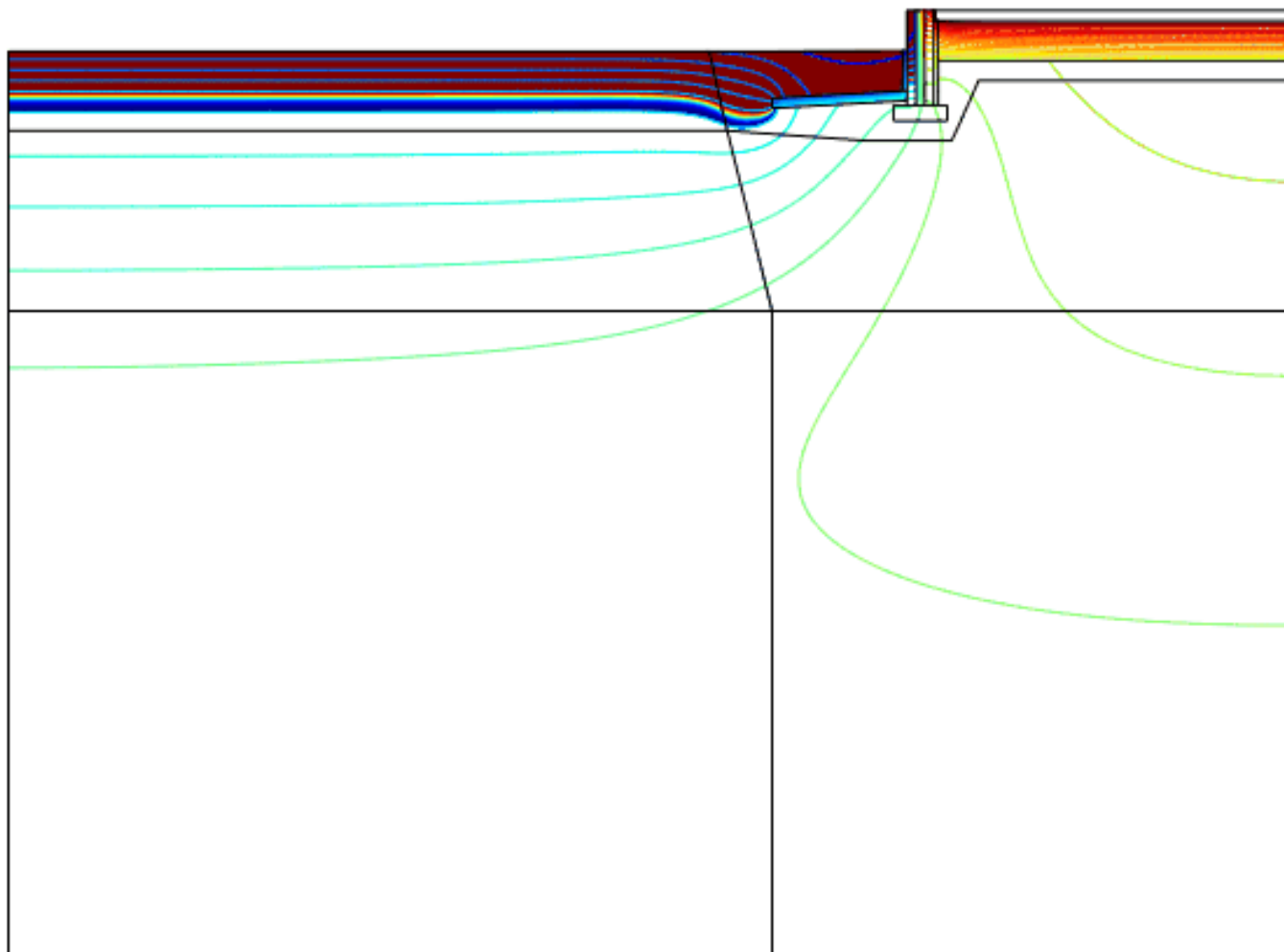
Coldest year in 50 years
Freezing index 48 700 Kh



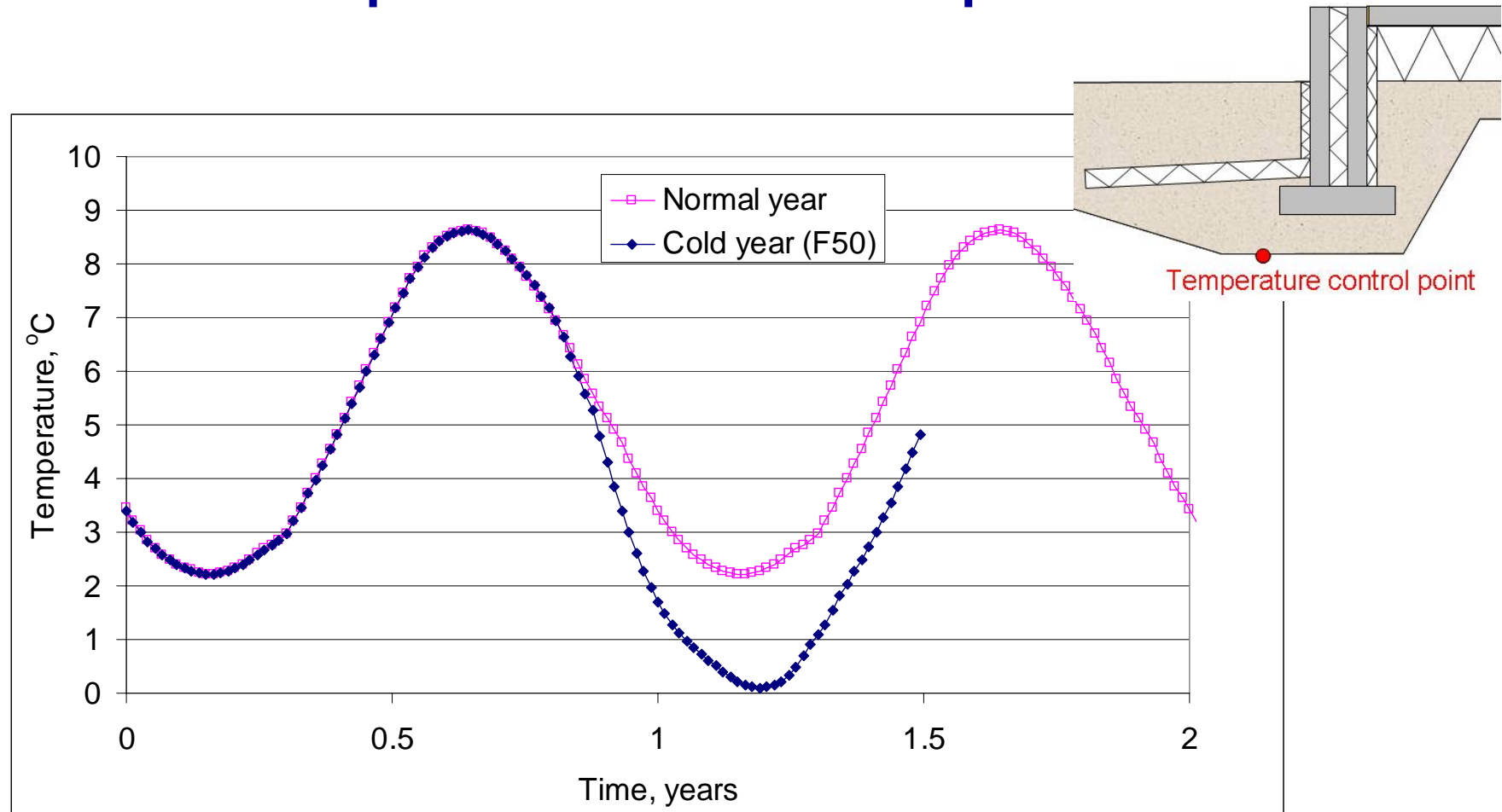
Example of frost penetration (next page)

- Floor insulation 400 mm
- Frost insulation width 1.5 m
- Frost insulation thickness 100 mm
- Frozen ground is coloured (color changes between 0 and -1 °C)
- Isotherms in 1 °C intervals

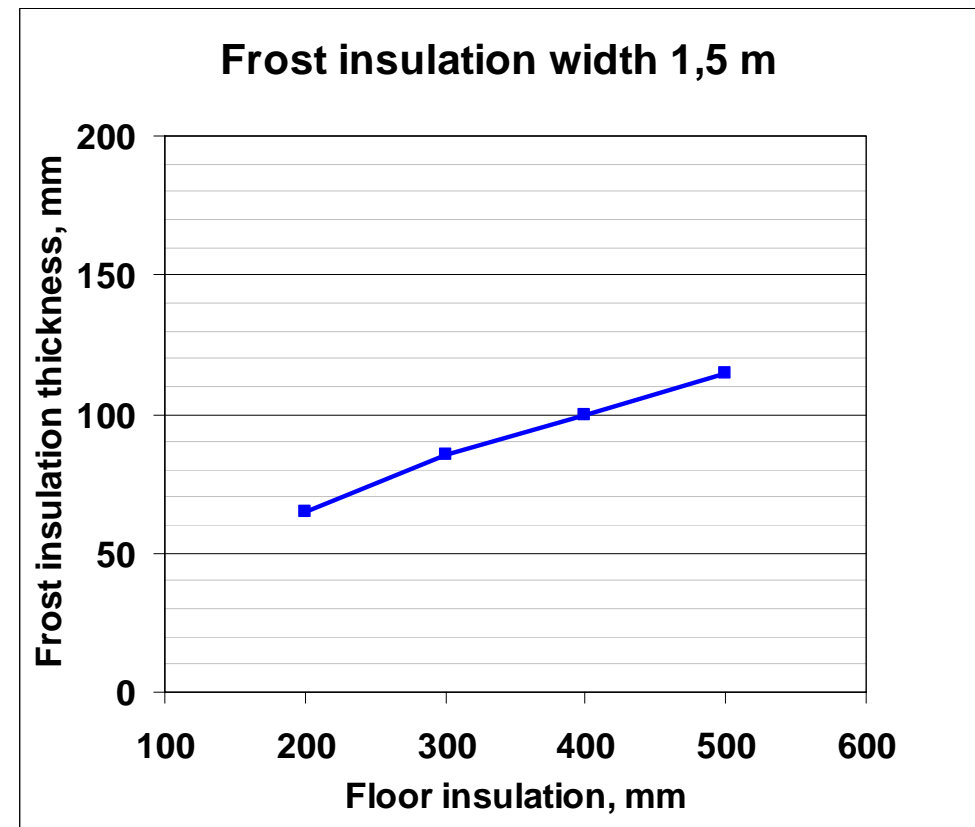
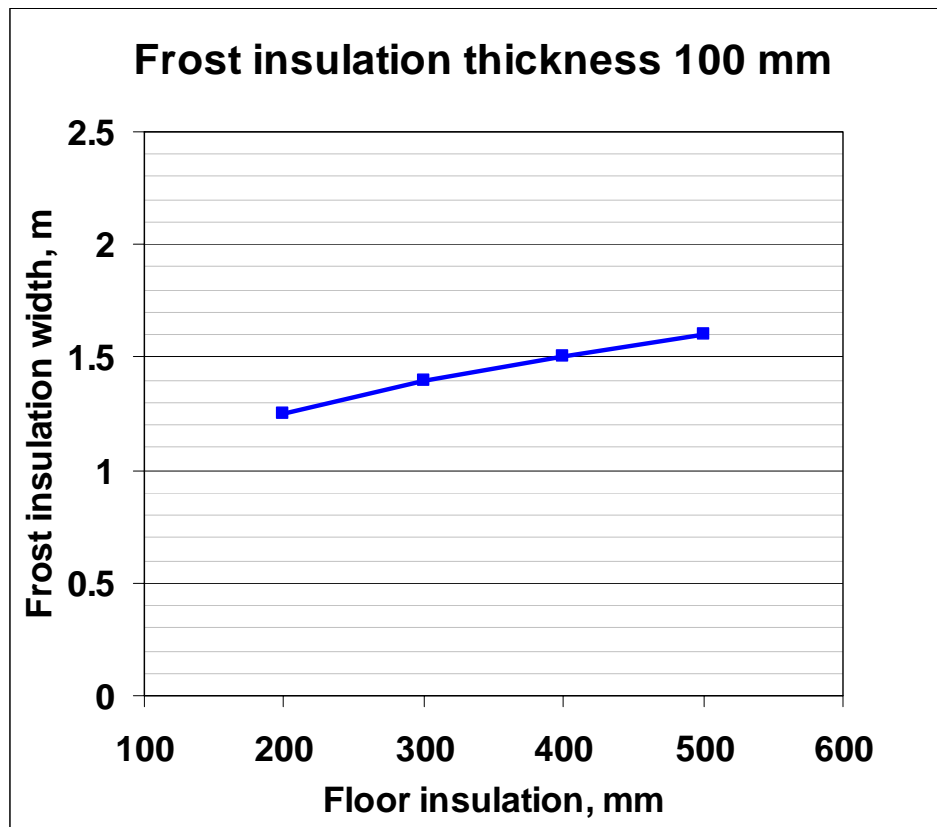




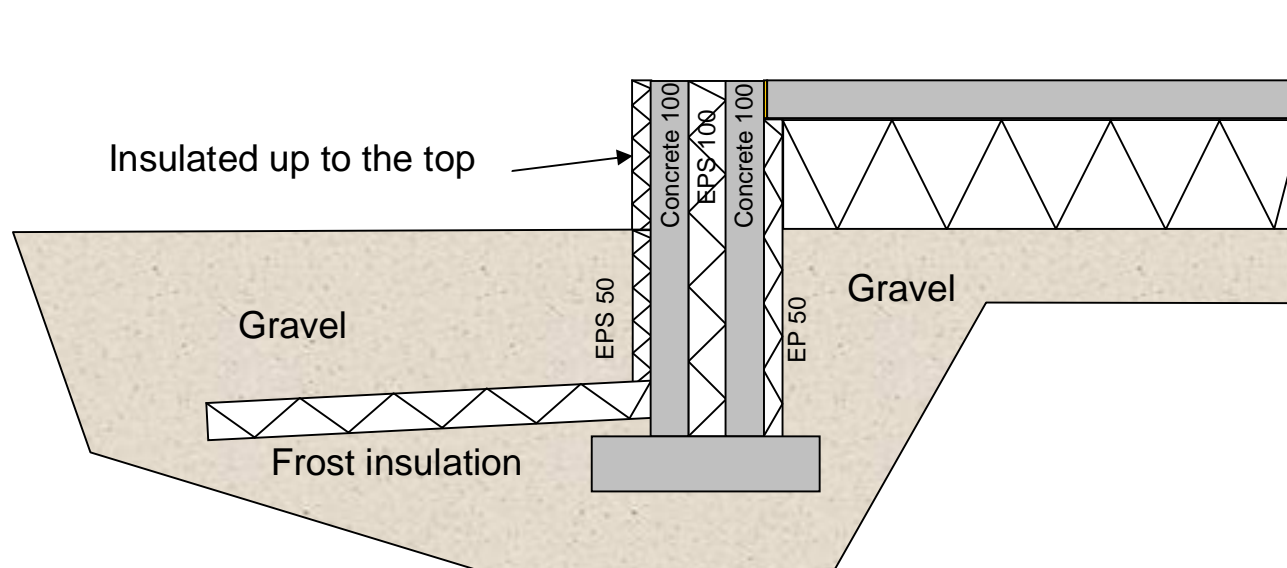
Temperature at the control point



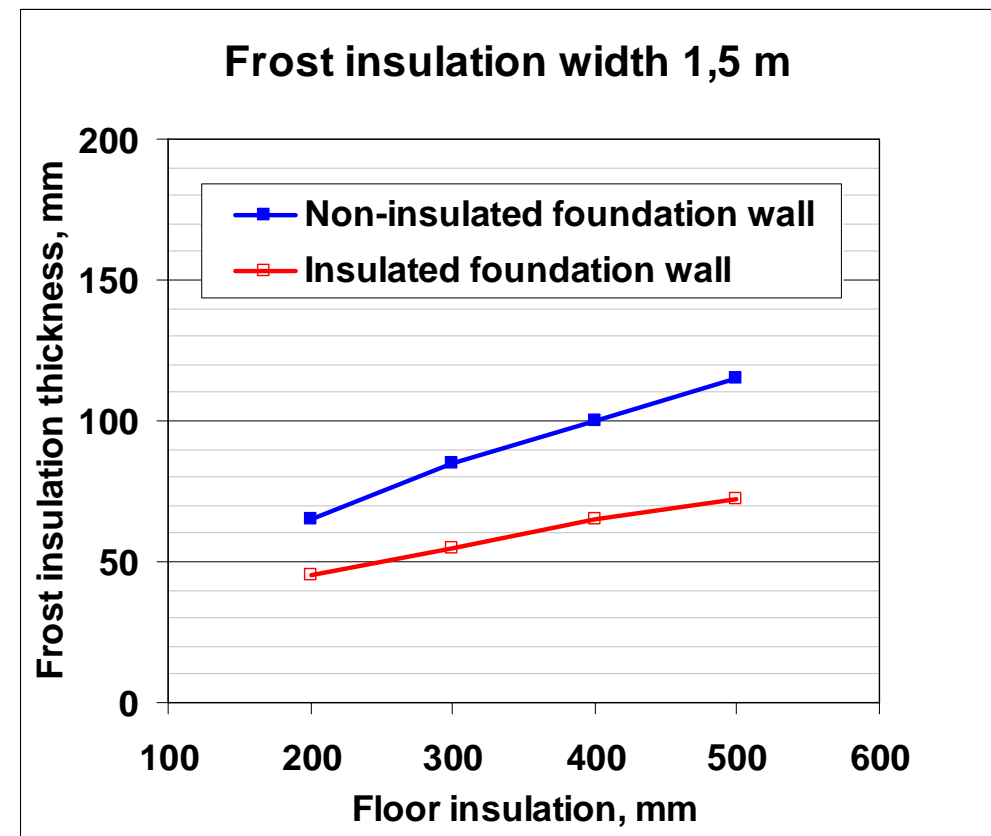
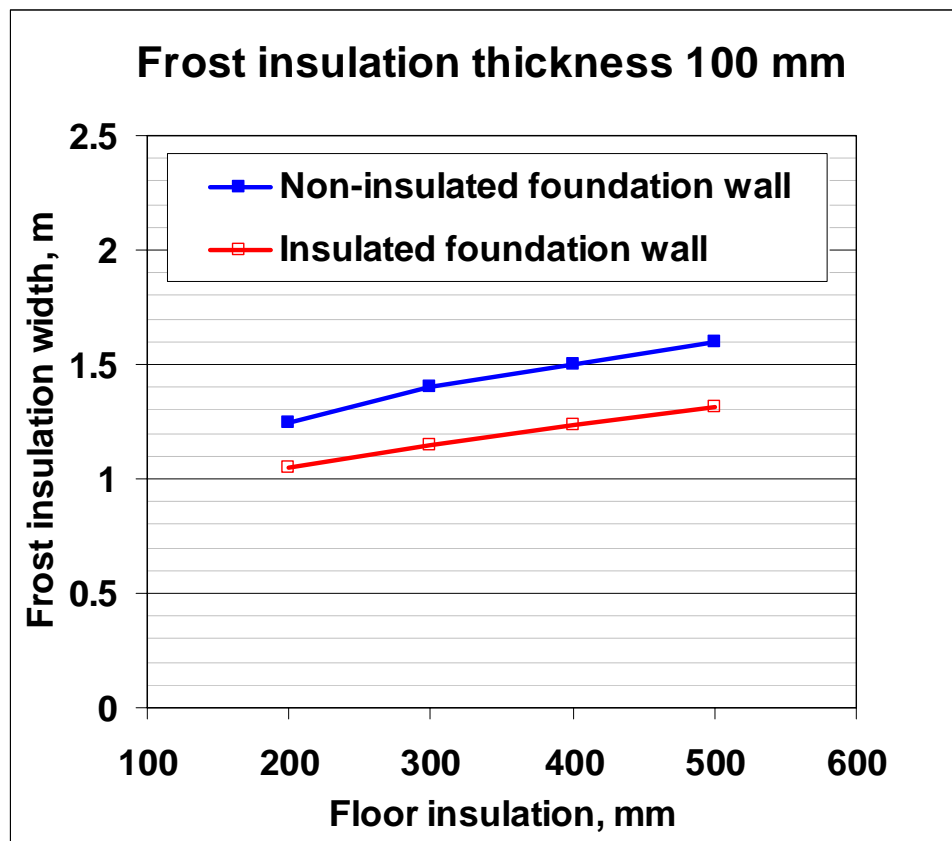
Effect of floor insulation on frost insulation dimensions



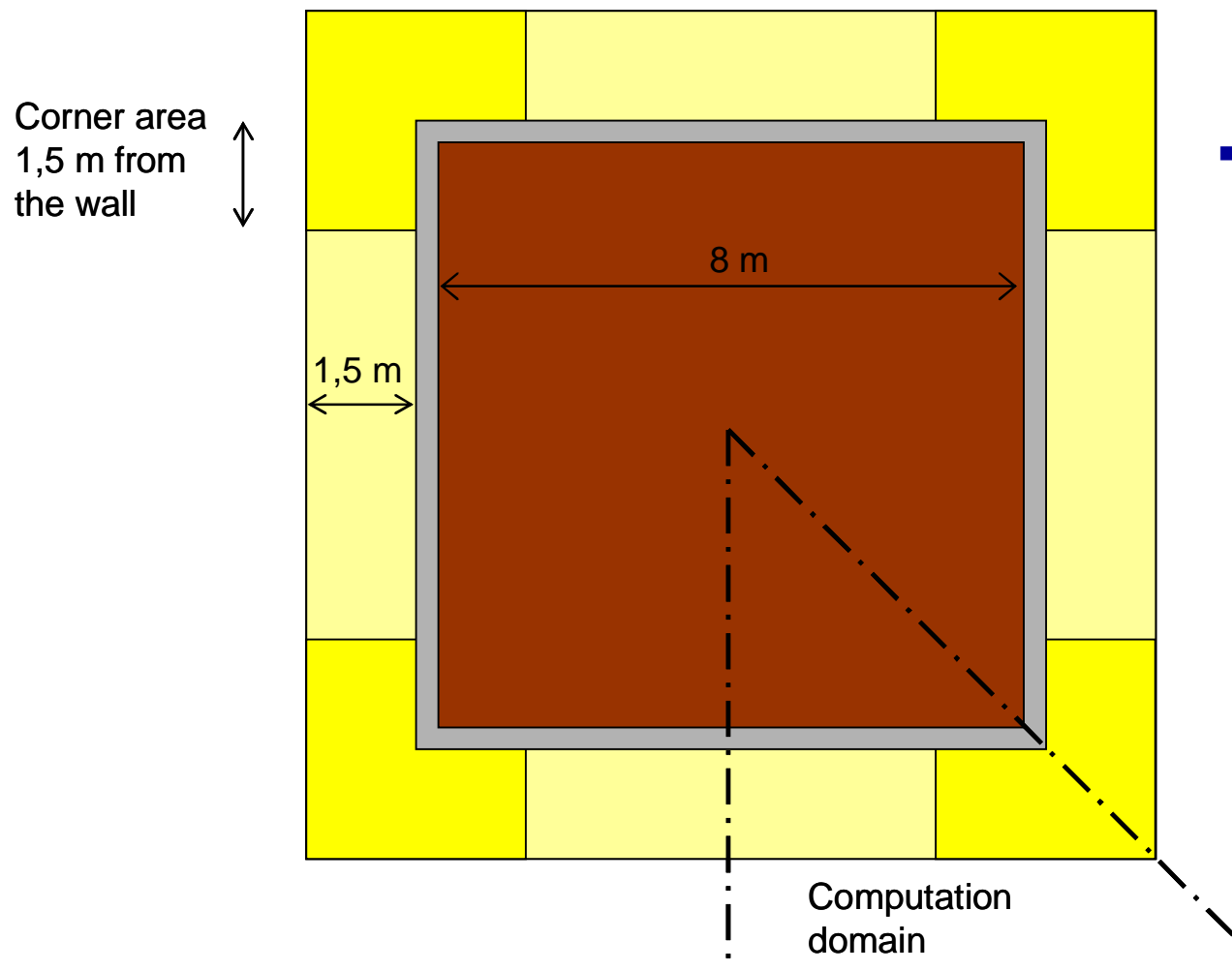
Foundation wall insulated also above the ground level



Effect of foundation wall insulation



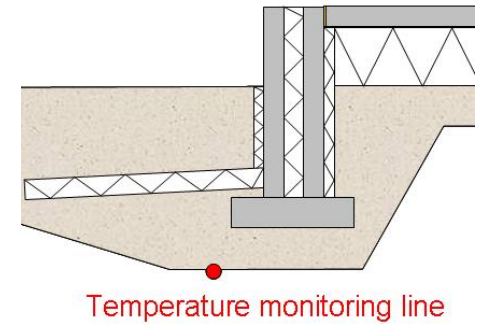
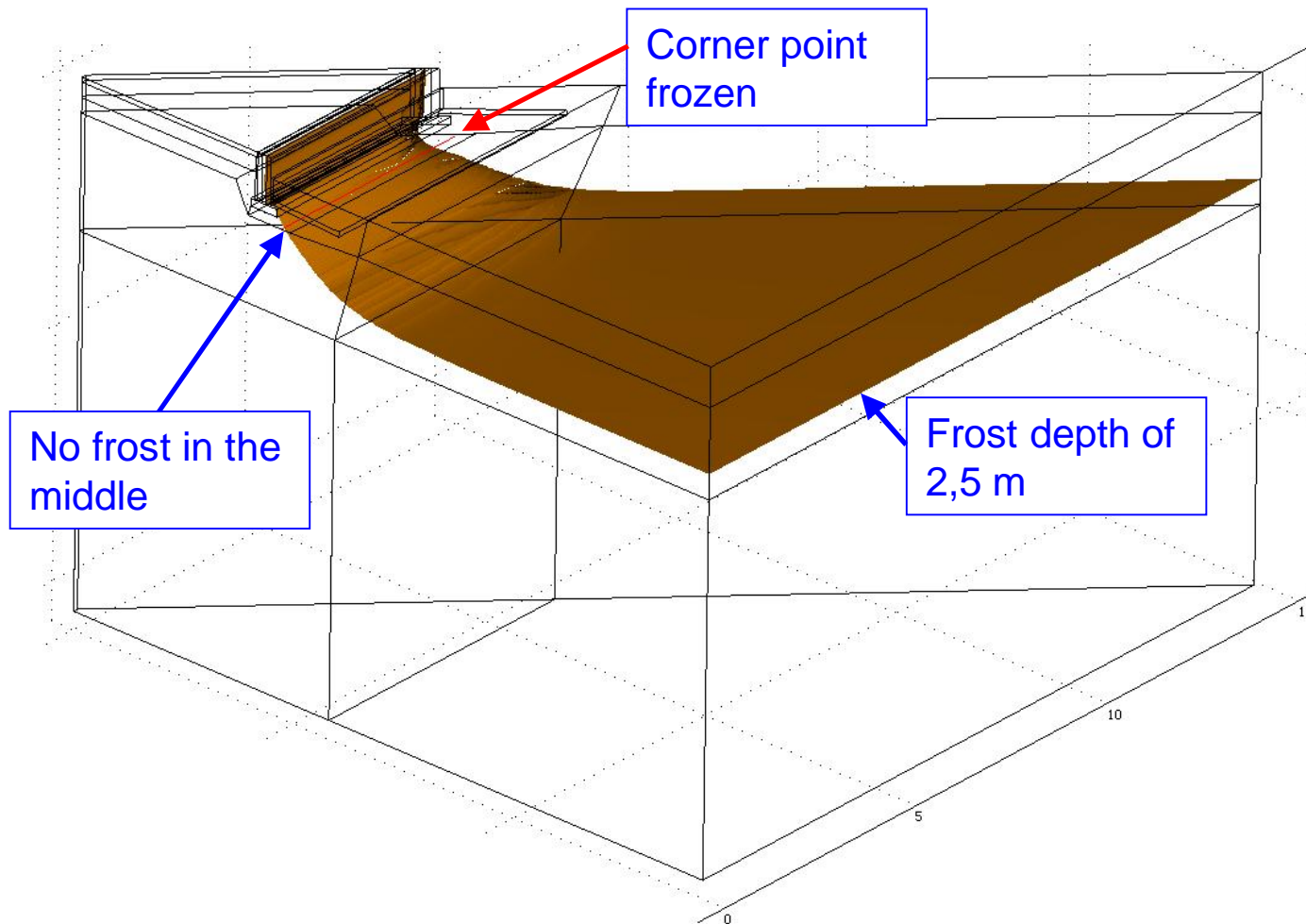
Frost insulation at building corner (3D simulation)



- Increase of frost insulation thickness in corners:
 - 0 %
 - 40 % (this is the recommendation in Finland)
 - 100 %

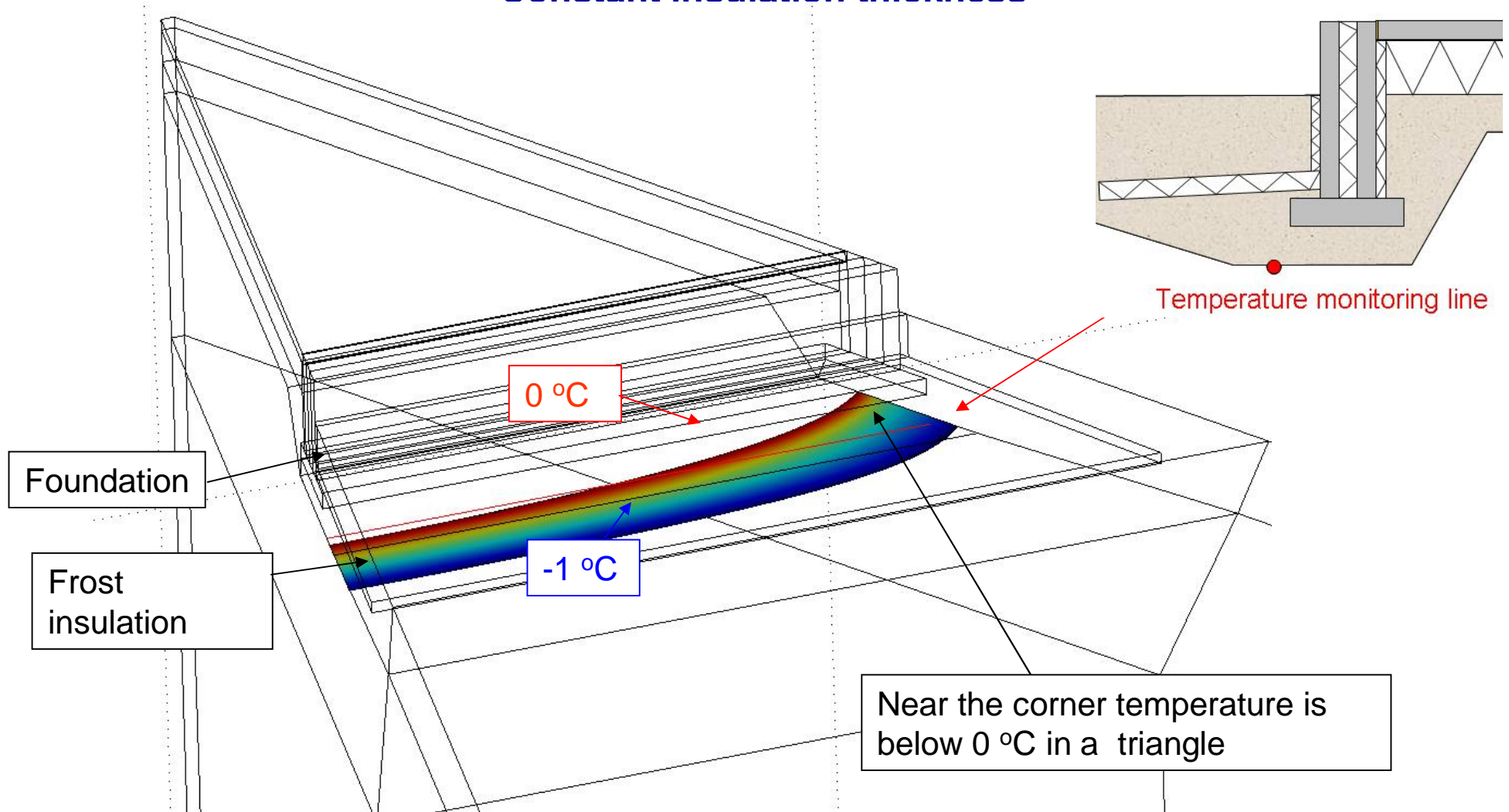
Frost penetration at building corner on March 28th

Constant insulation thickness



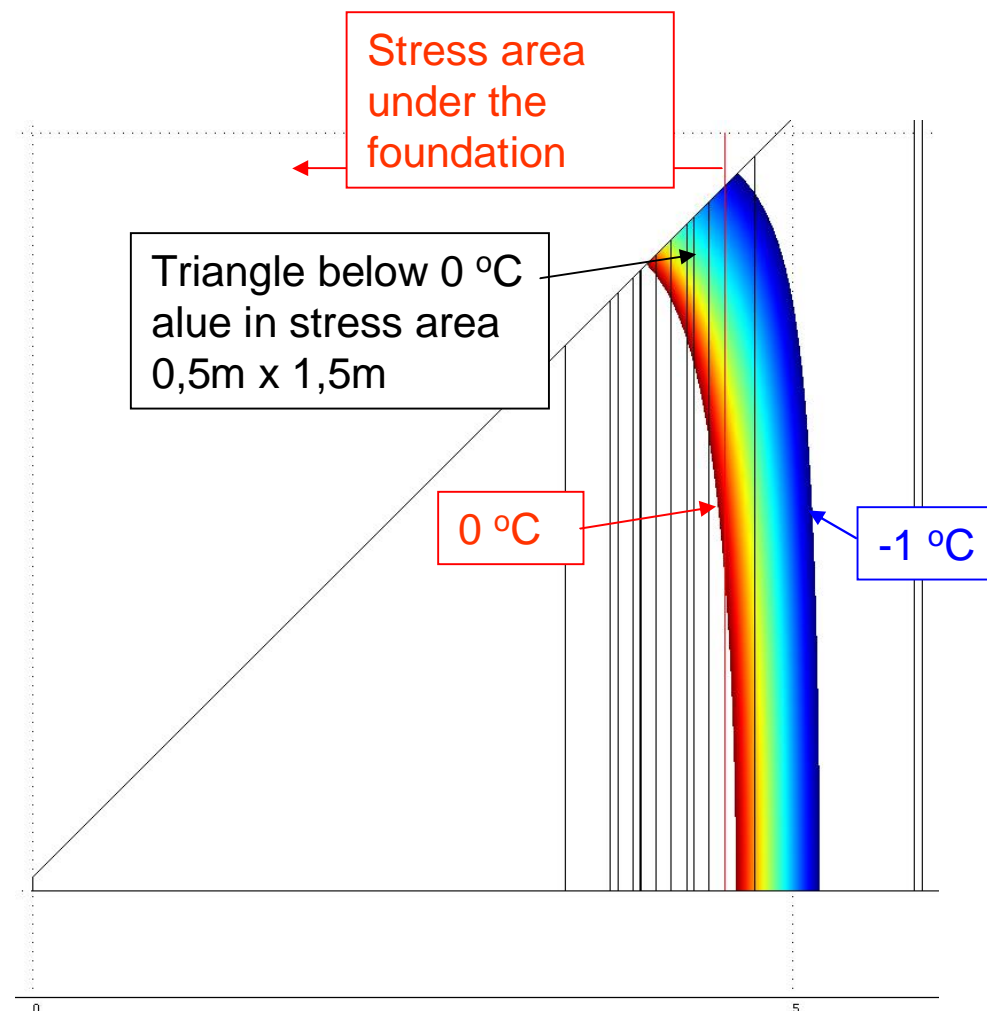
Frost penetration on March 28th 0,2 m below foundation

Constant insulation thickness

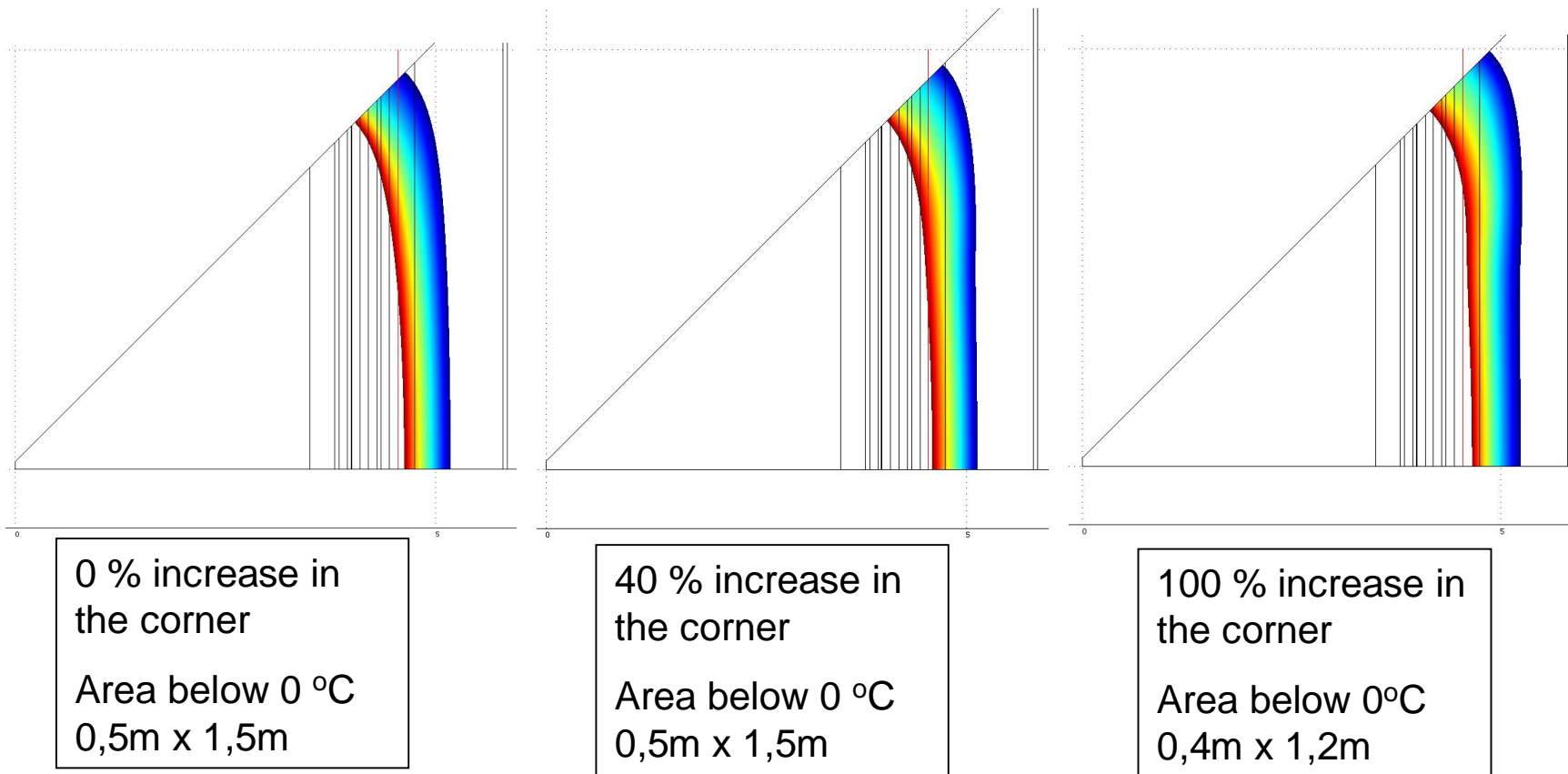


Frost penetration on March 28th 0,2 m below foundation

Constant insulation thickness



Frost penetration on March 28th 0,2 m below foundation Increased insulation thickness (0 %, 40% or 100%)

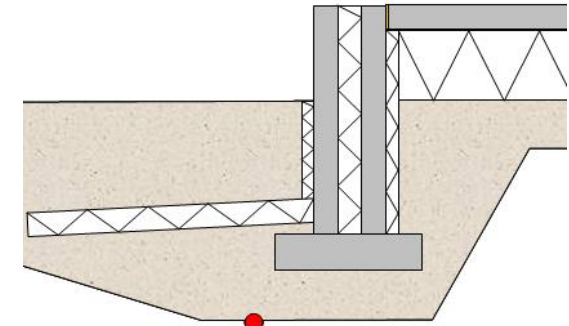
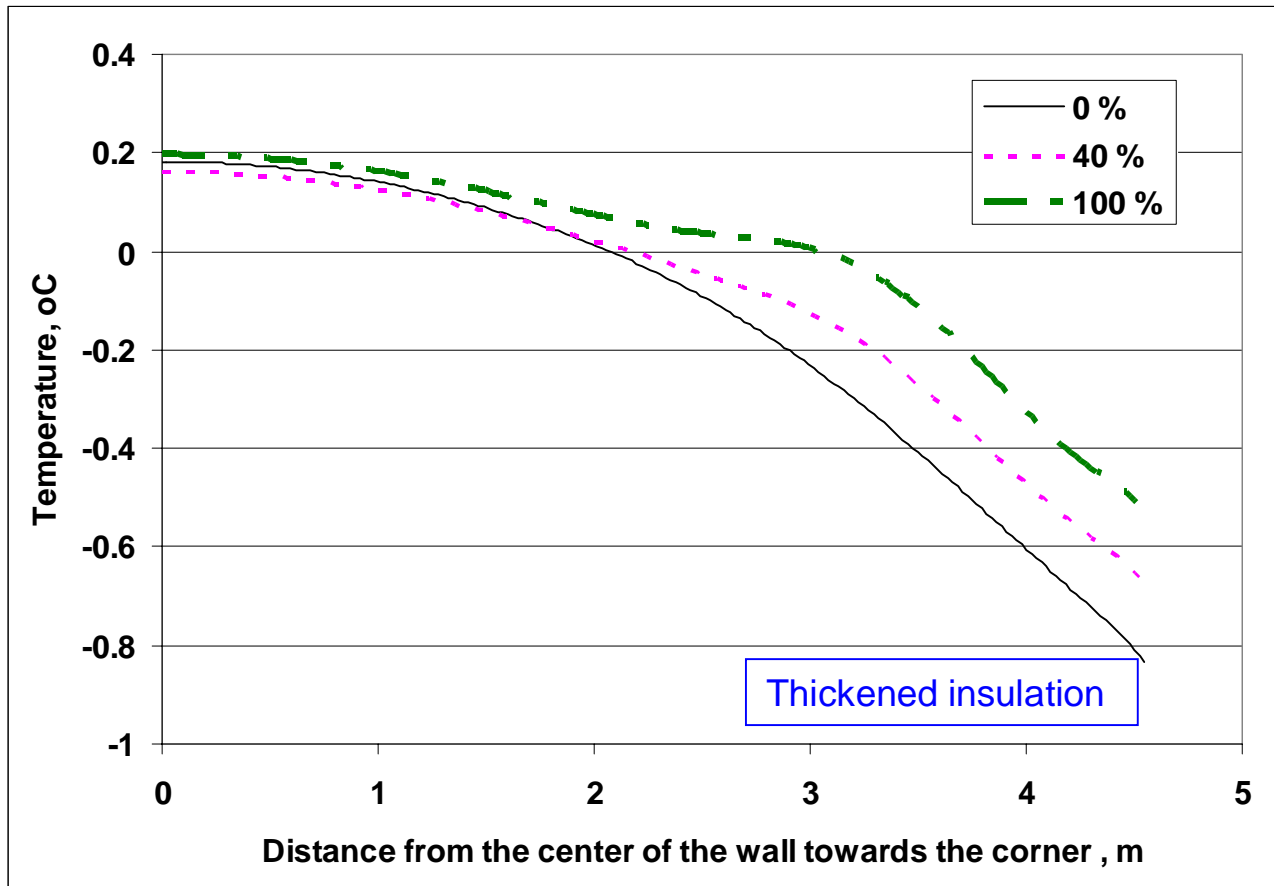


40% is the present recommendation in Finland

100% new recommendation?

Effect of additional insulation thickness near corners

March 28th



Temperature monitoring line

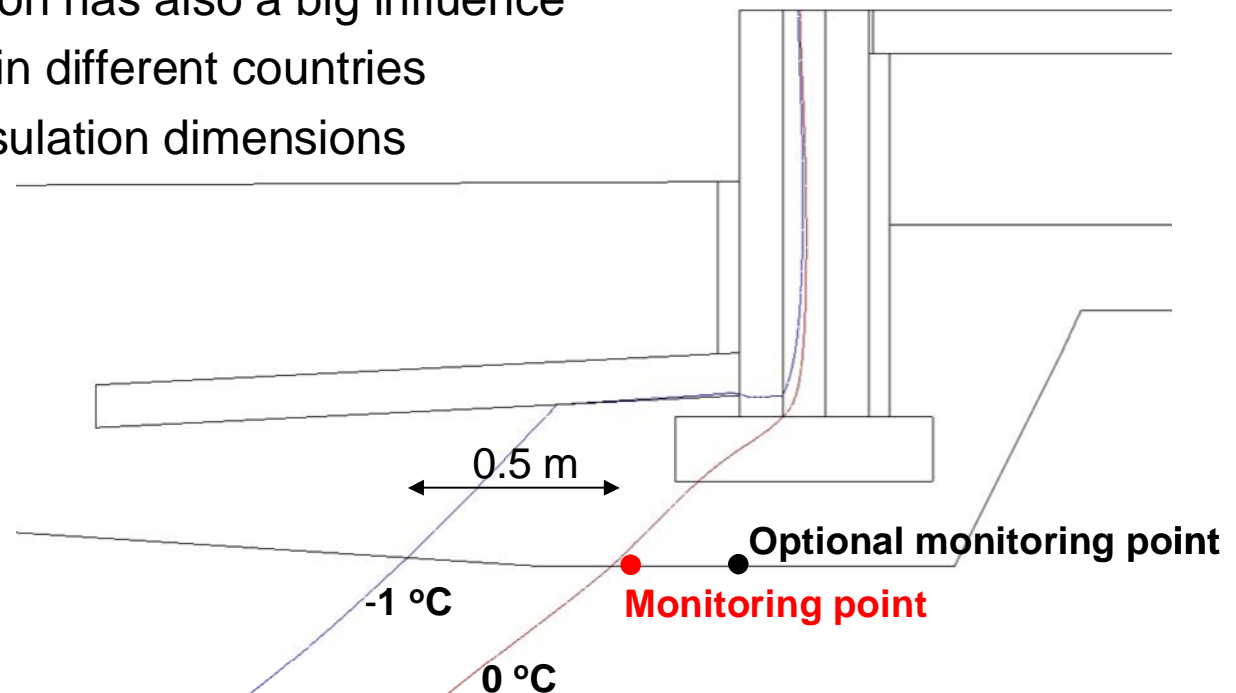
- Corner temperature increases slowly with increasing thickness
- However the area below 0 °C is getting smaller

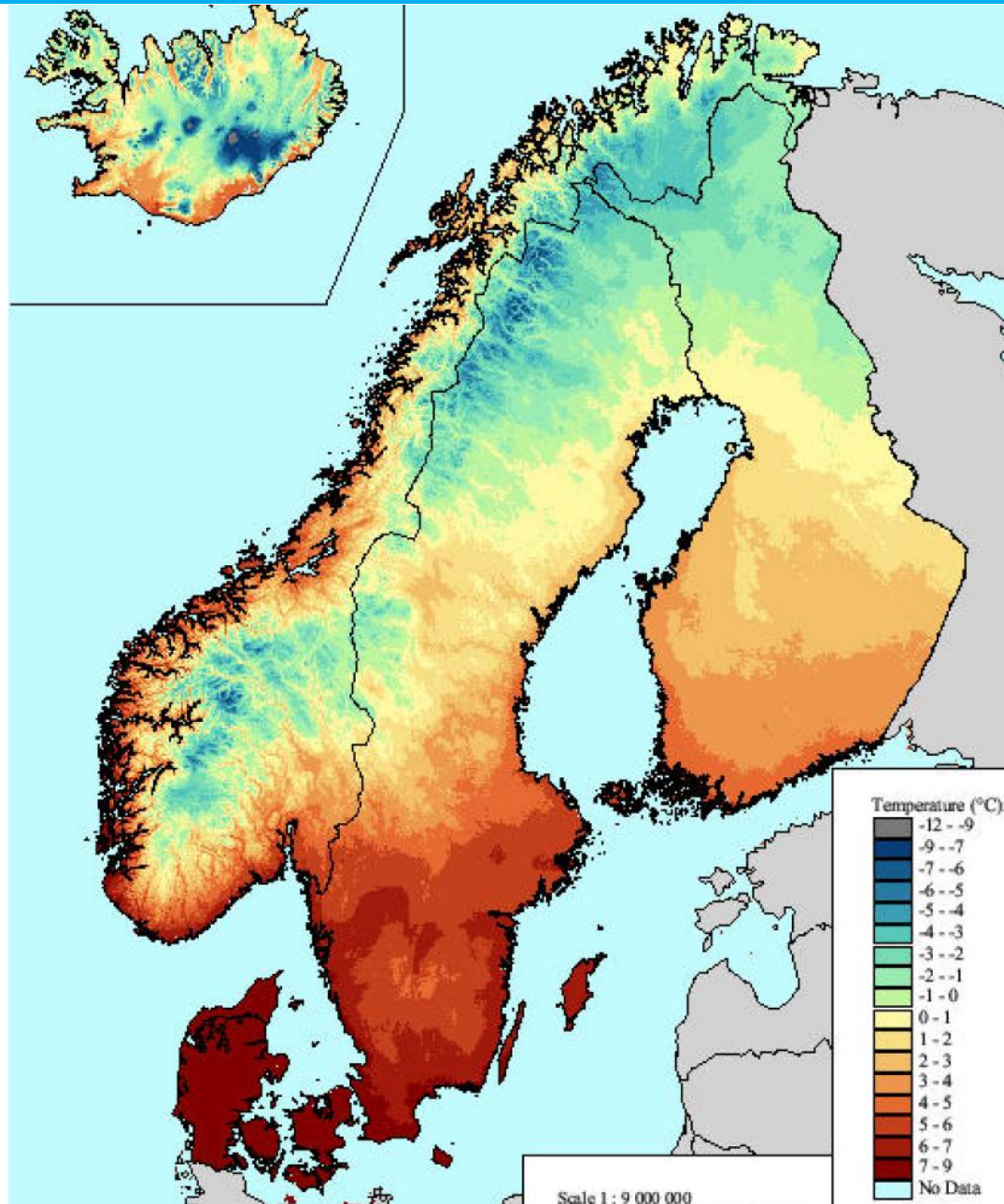
Summary for corners

- Present guidelines in Finland: 40 % increase of thickness in corners
- This practise has been working well: no problems if the guidelines have been followed
- Corner insulation recommendation is however based on very old research
- New 3D calculations show that corners need more frost insulation
- 100 % increase of thickness in corners will be recommended
- More research needed on corner frost protection

Effect of frost criteria

- Standard EN ISO 13791 (2001) gives two options for the critical temperature: -1 °C and 0 °C
 - Effect on frost insulation thickness is about 0.5 m (see below)
- Monitoring point location has also a big influence
- Different conventions in different countries
 - Different frost insulation dimensions





Mean annual temperature in 1961-1990



NORDKLIM – Nordic co-operation within Climate activities

Nordic temperature maps

O.E.Tveito, E.Førland, R.Heino, I.Hanssen-Bauer
 H.Alexandersson, B.Dahlström, A.Drebs, C.Kern-Hansen
 T.Jónsson, E. Vaarby Laursen, Y.Westman

Conclusions

- Effect of floor insulation thickness (200 – 500 mm) on frost insulation dimensions is remarkable
- Effect of foundation wall insulation is also important
- It is hard to keep the temperature above 0 °C in the corner
- Selection of the critical isotherm (-1°C or 0°C) and the selection of monitoring point have influences on the assessment of simulation results
- There is need for new research and international co-operation on all aspects of frost risks in the building foundations



**VTT creates business from
technology**