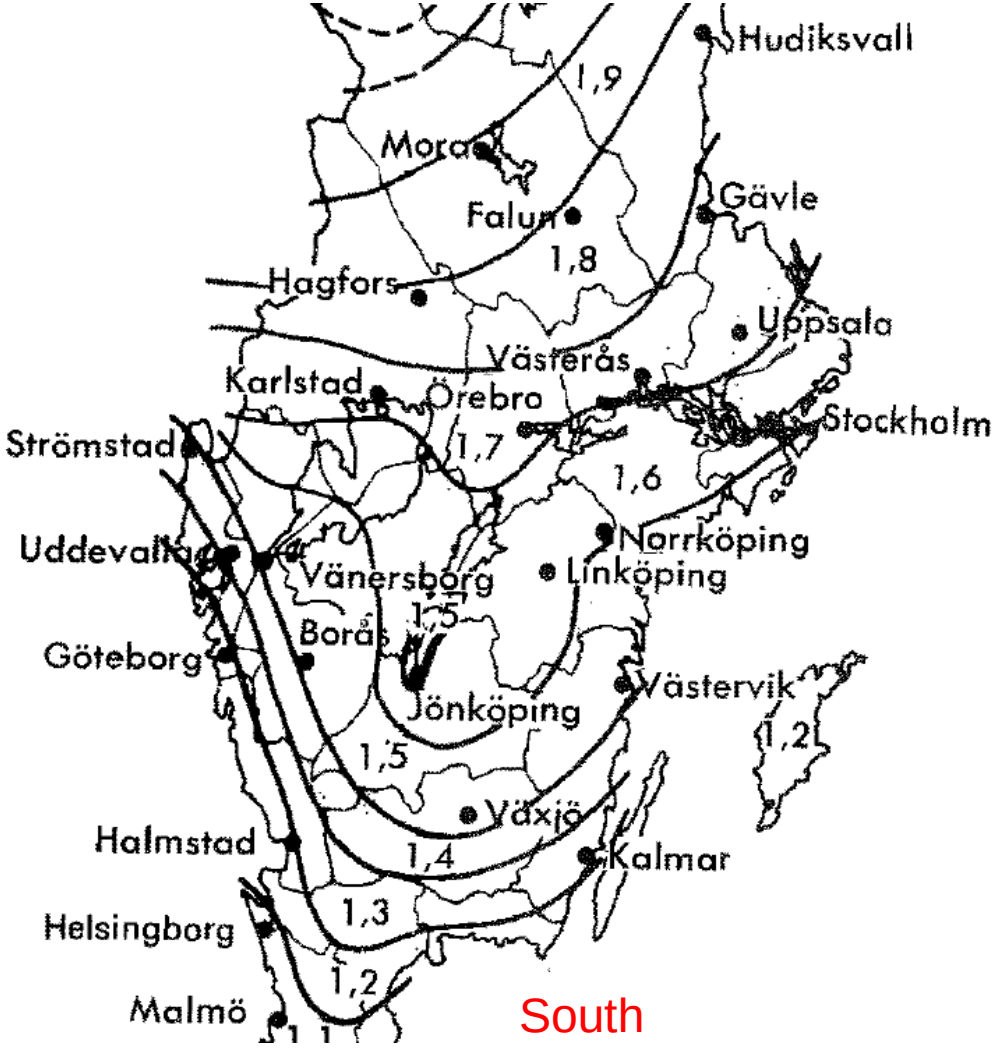
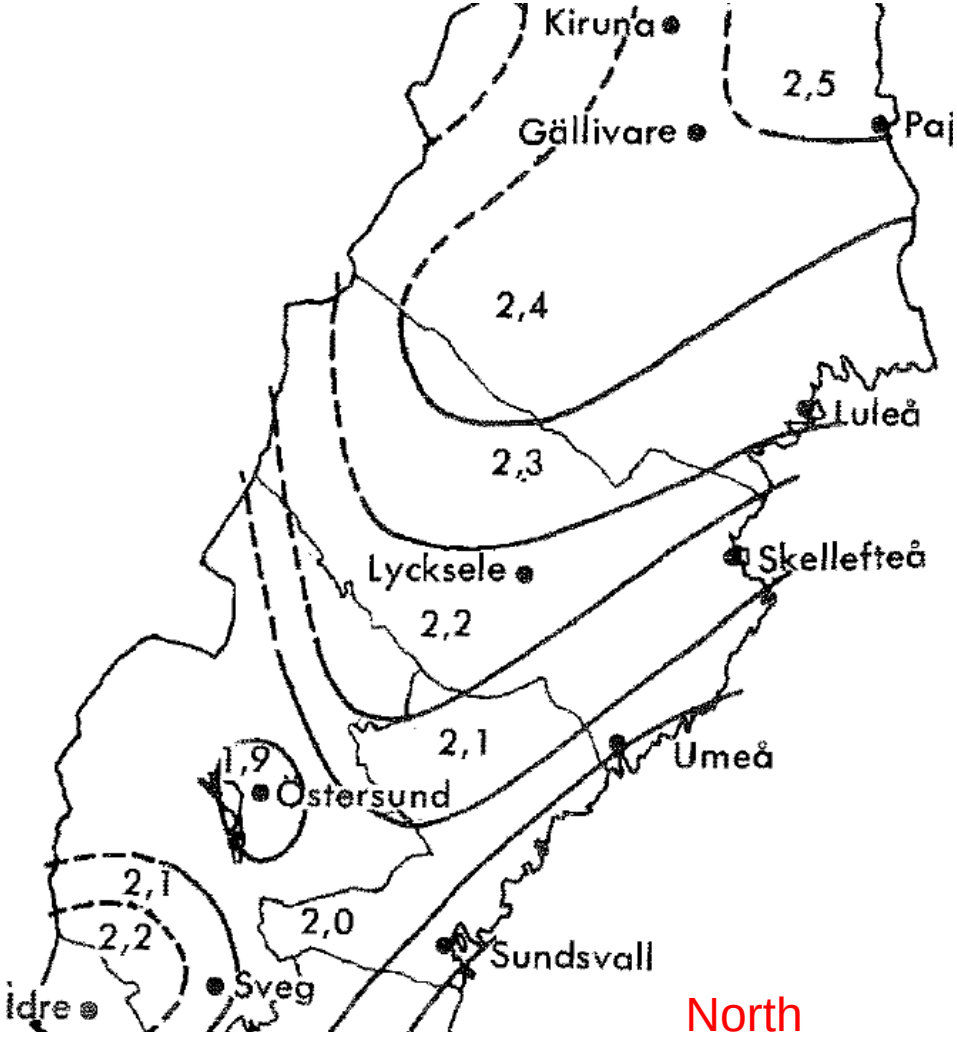
GROUND FROSTING ISSUE DOCUMENTATION - Sweden (2021)

The problem of ground frosting for foundations arises as a result of the freezing and thawing cycles of the ground between winter and summer. In the specific case of Sweden, for example, it is known that during the coldest period of the year ground frosting occurs for different depths between the Southern and Northern regions of the country, respectively for more than 2 meters and for at least 1,10 meters deep.



South

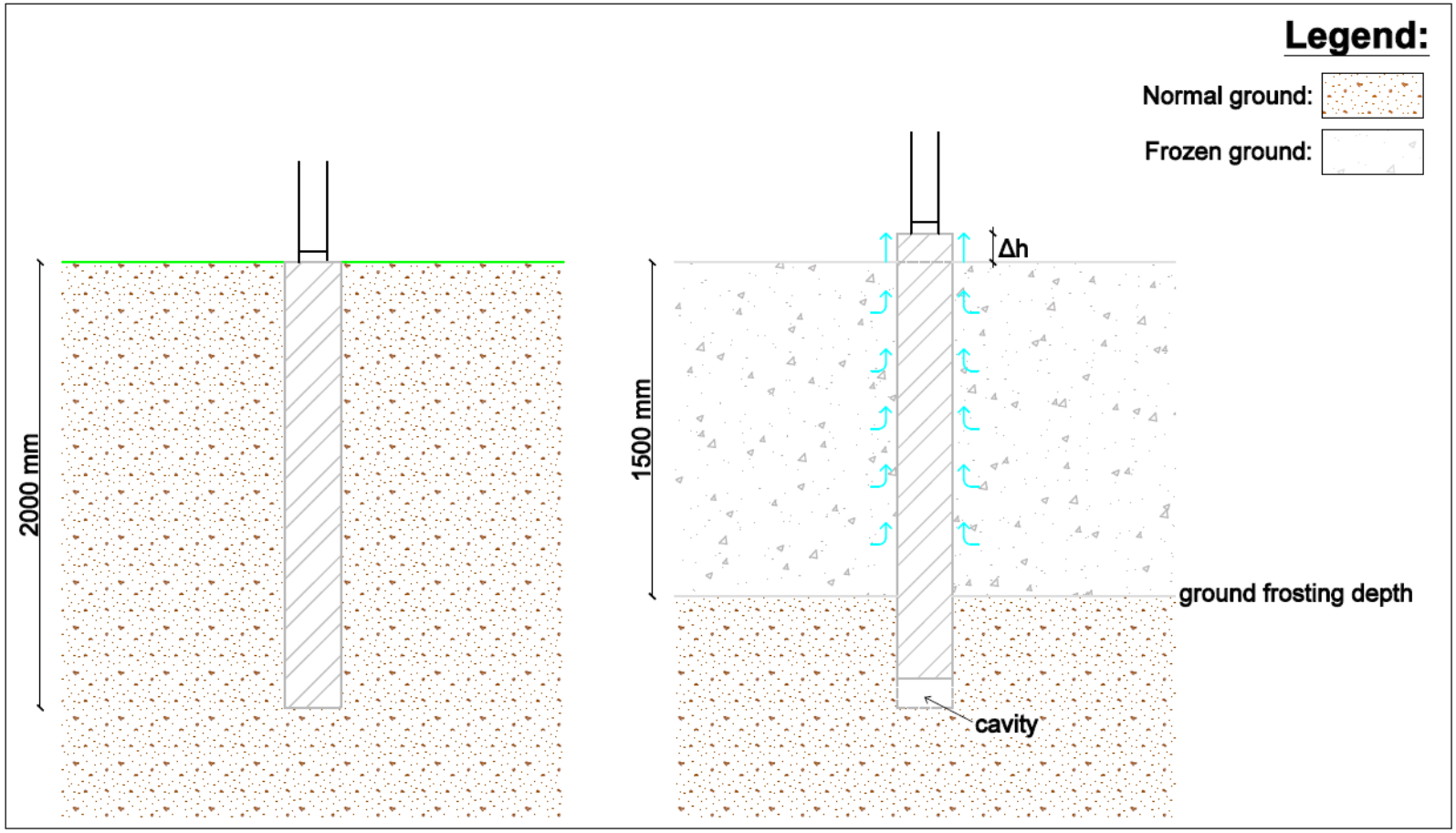


North

EFFECT ON PILE FOUNDATIONS

The low temperatures of winter produce a progressive freezing of the interstitial water in the soil, which increases in volume (with respect to the liquid volume, the increase in the volume of ice at T=0°C is 8,68%). This is confined downwards by the presence non-frosted soil, implying that the increase in the volume of frozen water determines a vertical movement of the soil upwards. Taking as example a pole with 250mm diameter and 1500mm length (partially immersed in frozen soil and partially in thawed soil): when the surface soil freezes, the pole is pushed upwards of 13cm; the lateral expansion in the area surrounding the pole is prevented by the same presence of it.

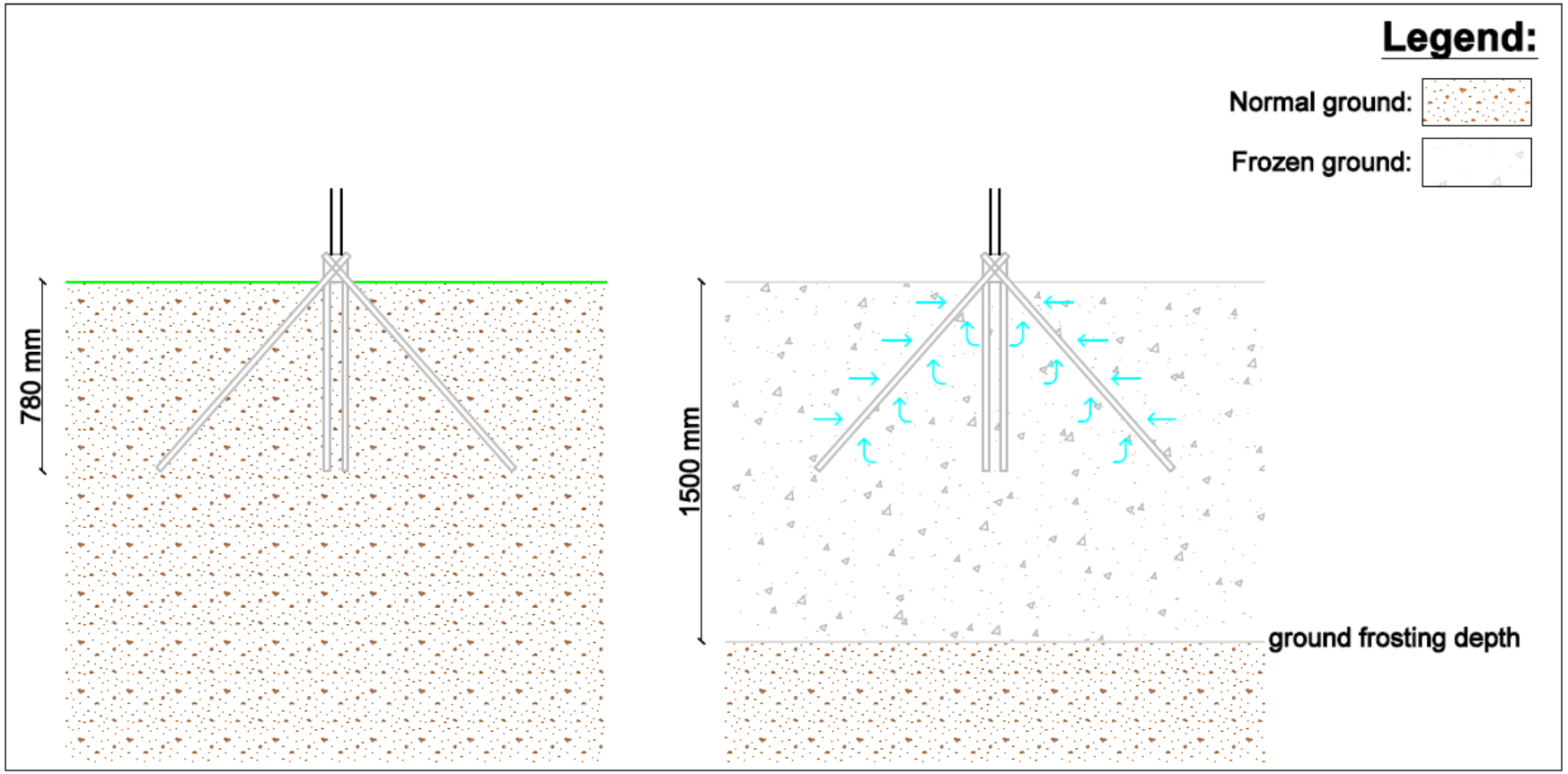
This causes the pole to detach from the bottom of the hole, losing its peak bearing capacity, and once the ground around the pole has thawed, it is altered by the sliding of the pole which tends to return to the initial position, also losing some of the lateral bearing capacity. This said, it can be concluded that, following several cycles of freezing and thawing, the performance of the pole is progressively reduced in relation to the stability of the structures connected to it, and that the pole tends to be "expelled" from the ground.



EFFECT ON TREESYSTEM™ FOUNDATIONS

Let's now consider the oblique inserts of the Treesystem foundation. The maximum driving depth that can be reached using the longest inserts among those available (1190mm), inclined 41° with respect to the vertical, is equal to 780mm, a reduced depth that allows the foundation to be completely immersed in the frozen ground and which helps against the instability induced by ground frosting (as stated in the following article: https://www.solarpowerworldonline.com/2018/11/keeping-solar-arrays-mounted-in-frost-heave-susceptible-soil/).
If we repeat the reasoning previously made for the pile, considering 4 inserts with 1190mm length and 25mm diameter installed vertically, the increase in the volume of the soil corresponds to an overall vertical displacement of the foundation 1,5 times lower than that of a pole with 250mm diameter; the situation would penalize the Treesystem foundation.

This is why the inserts are not installed vertically but inclined of 41°, which implies that the freezing of the ground not only occurs in a vertical direction, but also has a stabilizing horizontal component that limits the actual possible displacements of the foundation.



OTHER AVANTAGES OF TREESYSTEM™ AGAINST GROUND FROSTING (FROST HEAVE)

- As reported in the following article https://www.solarpowerworldonline.com/2018/03/avoiding-costly-consequences-frost-heave-solar-ground-mounts/, foundations that are wider below the frost line can help the pole resist frost lifting. Given the geometry of the TreeSystem foundation, it can be said that the foundation is more stable than a classic plinth or a pole, because the area of land interested by the foundation is a triangle with the vertex facing up. Moreover, a stabilizing contribution is generated by the lateral volumetric expansion of the soil.

  Sometimes, triangular plinths are used to fight the issue; TreeSystem anchoring has the same effect but with a much easier installation process.

- The use of hot-dip galvanized steel helps to ensure a good foundation performance: the hot-dip galvanizing process of the steel, in fact, allows the metal to “have good protection against corrosion and lifting caused by frost, since corroded steel tends to have higher frost adhesion values" (as stated in the following article: https://www.solarpowerworldonline.com/2018/03/avoiding-costly-consequences-frost-heave-solar-ground-mounts/).

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