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Exclay Internordic Geoproject (LWAgeolight)
”The depth of an insulation layer”

Summary

Expanded clay is a good material for frost insulation on frost susceptible soils and for lightening of road embankments on soft soils. Still there has been one problem; it may cause sudden slipperiness in the beginning of a winter when other roads are not slippery yet. The target of this study is to find the depth for the insulation layer where there is no risk for the icing. At first some friction measurements were made on a couple of existing exclay-insulated roads in Helsinki and Espoo during the winter 1999-2000. Then a large test site with different depths of the exclay layer was built near Helsinki. The test site was instrumented with sensors measuring the temperature as often as wanted. The friction measurements were continuing on the test site during the winter 2000-01. The friction values have not shown the potential of the exclay-insulated sections to be more slippery than the section without exclay, although theoretical calculations have shown the possibility very clearly. Maybe the previous two winters have both been exceptional. It is obvious that more data is needed to be sure what the sufficient depth of the exclay layer should be to avoid dangerous slipperiness.

1. Introduction

Expanded clay (exclay) is a good material for frost insulation on frost susceptible soils and for lightening of road embankments on soft soils. It's heat conductivity is normally 0,16…0,20 W/mK and it's unit weight is 3…4 kN/m^3. One problem is still to be solved; how to avoid sudden slipperiness especially in the beginning of winter when the heat of the earth is not able to melt the ice because of the insulation layer. That is why the road authorities in Finland demand that insulation layers should be covered with at least 0,7 m thick layers of bound or unbound aggregates. In Sweden the corresponding minimum thickness is 0,5 m and in Norway only 0,3 m. The main idea of this research is to find out how often that kind of slipperiness occurs in different places and what kind of influence the depth of the insulation layer has to the slipperiness of the road.

2. Description of the project

The project in Finland is a part of the "Exclay internordic geoproject" (Geolight 2001=>) that has been started by Optiroc of Norway. From the end of 1998 to the end of 1999 the project was in preliminary stage. Actually the project has been going on in Finland since the end of 1999. This research is a continuation to the “MiljoIso” project which was carried out by SINTEF (Civil and Environmental Engineering, Geotechnical Engineering) and Optiroc of Norway during 1997…1999. That project was concentrated to the basic properties of exclay. This research concentrates on the behaviour of exclay structures.

On frost susceptible soils exclay is used as frost insulation material and on soft soils exclay is used to reduce settlements of road embankments. The aim of the research is to improve the usage of exclay in these solutions and to make constructing and repairing of streets and roads with exclay more cost effective.

To achieve this aim one potential way is to reduce the thickness (and the weight) of aggregate layer above the exclay layer and in that way to decrease the amount of exclay and the amount of excavations needed to achieve the hoped low weight of road embankment. By reducing the thickness of the layer over exclay it is possible that the risk of icing of road surface will increase especially during autumn when the air temperature goes under zero degrees. This may cause some uncontrolled slippery risk for the road surface or danger to traffic. Investigating of this icing risk is an essential part of the research in Finland.

In Finland the research participants besides Optiroc Oy are the Finnish National Road Administration (FinnRA) and Kaitos Ltd. as financiers and Helsinki University of Technology (HUT, the laboratory of Highway Engineering and the laboratory of Soil Mechanics and Foundation Engineering) and SCC Viatek Ltd. as researchers. Other financiers are Nordic Industrial Fund, Nordtest and Norwegian Research Council. There are also other researchers in Norway and in Sweden (Sintef, VTI). The project manager of the whole project is Kjell-Owe Amundsgård from Norwegian Optiroc.

3. Icing themes

The icing group of the project is working mainly on two subjects:

- Determining the risk of slipperiness by theoretical calculations
- Measuring the friction of the test structures

The relative humidity of the air is in Finland in winter time usually approximately 90 % (75…98 %). The dew point temperature is in winter time 0,5…4 °C lower than the air temperature, the average is 2 °C. When the temperature of the road surface goes under the dew point temperature (and < 0 °C) the air humidity will cause ice on the surface. The risk of slipperiness can be determined by calculating the periods when $T_{surface} < 0$ °C and $T_{surface}-T_{air}>-2$ °C.

Thermal data has been collected from:

- Sandmoen test site in Norway during the winters 1999-2000 and 2000-01
- Tuupakka test site in Southern Finland during the winter 2000-01
- Kattilakoski-road in Northern Finland 10-12/98, 10-12/99 and 10-12/00

Only thermal data from Tuupakka test site has been handled shortly in this article.

The friction measurements have been done in Helsinki and Espoo on two roads with exclay during the winter 1999-2000 and on Tuupakka test site during the winter 2000-01.

4. Friction measurements 1999-2000

The first task was to find two test roads for the friction measurements. In Helsinki area there were six potential roads built with exclay situating so that a comparative section without exclay was very near. Two roads from those six alternatives were chosen, because the winter maintenance was similar on both the exclay section and the section without exclay. Also the traffic volumes of both sections were nearly the same.

During the winter 1999-2000 the friction coefficients were measured by pushing a *portable friction tester PFT* (owned by The Swedish national Road and Transport Research Institute, VTI). The PFT has three wheels, of which one measures the friction. The tyre pressure is 1,25 bar and the weight of the apparatus is 38 kg. The measuring speed is 0,5 m/s. The PFT gives an average friction of eight measurements on every 104 mm. After pushing 3 m there will be approximately 250 measurements and nearly thirty average values. The normal procedure was to push such a three meter section four times twice on both vehicle paths. Some friction measurements were also made with a car owned by FinnRA (Finnish Road Administration).

The results did not indicate that a road containing exclay would be more slippery than other roads. Maybe the measurements were not done at a “right” moment, because sometimes the roads were salted just before the measuring was to begin. Naturally there was no use to make friction measurements on a salted road. The car measurements were only training, but during the summer 2000 The laboratory of Highway Engineering invested in a new car including a friction tester installation (C-trip).

5. Test site at Tuupakka intersection

The test structures are located on a bus ramp in Tuupakka interchange on Ring Road III (National Highway E18, figure 1). Exclay is used to lighten the weight of the road embankment on soft soil. A summary of the structures of the test site has been gathered in table 1. It gives a general picture of the test structures at Tuupakka. At Tuupakka there are also some other test structures concerning georeinforcements of the road structure, but these results are out of the item of this article.

The construction of test structures took place during the summer 2000. Exclay manufactured by Optiroc Estonia was used at the site. The normative grain size was 10…20 mm. Exclay layer thicknesses of 0,7…1,45 m were used.

Table 1. Test structures of Tuupakka.

Number of the structure	Thickness of the layer above the exclay layer	Length of structure	Station numbers
1b	no exclay	15 m*	355…370
2b	0,7 m	15 m*	370…385
3.1b	0,5 m	15 m*	385…400
4.1	0,35 m	15 m*	400…415

* structure instrumented with thermo couples

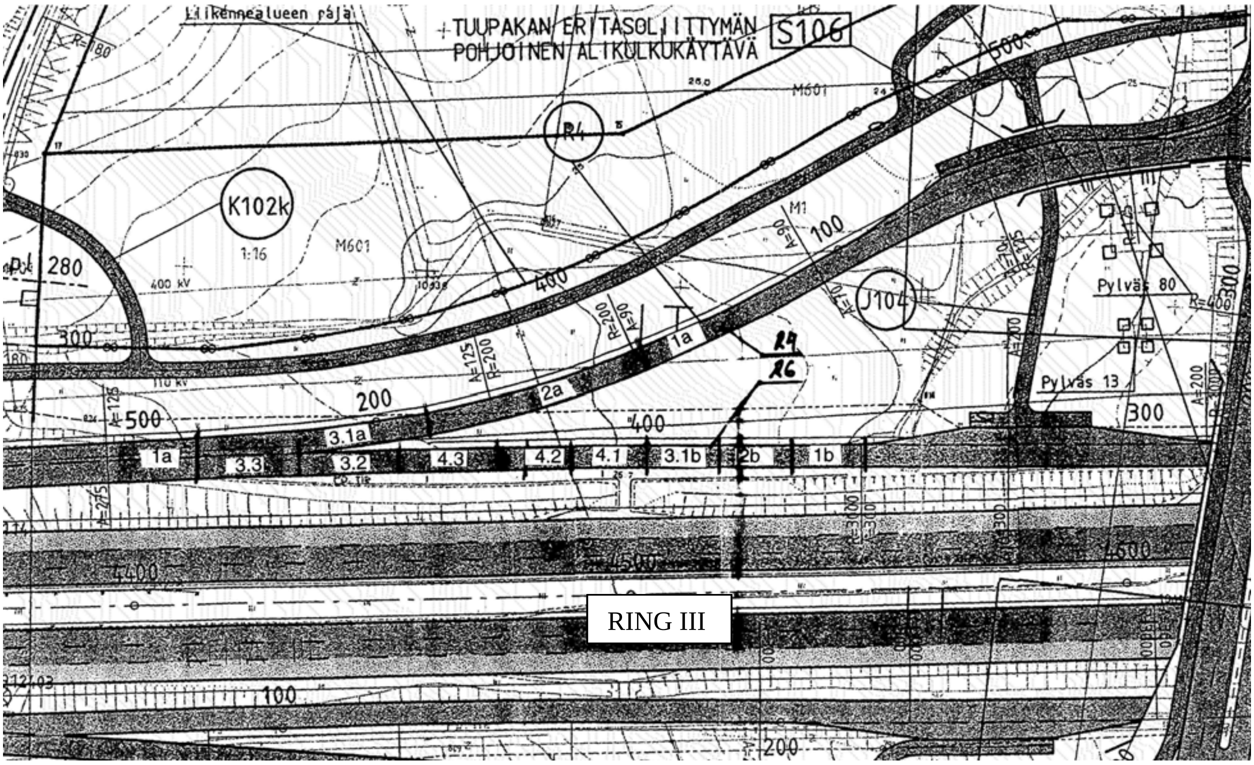

Figure 1. Location of the test structures at the test site of Tuupakka. Structures 1b, 2b, 3.1a at the bus ramp R6 have been used for researching the icing of exclay structures.

Crushed aggregate was used in the base layer in station numbers 355…400 and 450… . Reclaimed concrete was used in the base layer in station numbers 400…450. In the sub-base layer crushed aggregate was used on numbers 355…400 and 450…490 and blasted rock after station number 490. The thickness of the base course asphalt concrete was 50 mm. The asphalt wearing course was 50 mm thick. The test structures were opened for normal traffic in the beginning of October 2000.

6. Comparison test of different friction measuring equipment

In December 2000 a large comparison test of friction measuring equipment was arranged in Lappland. FinnRA took care of financing the project and VTT (Technical Research Centre) made the arrangements and reporting. The focus was in winter circumstances. One of the main targets was also to make suggestions of how to make friction measurements with a car and a C-trip. Fortunately it was possible to include also the PFT in the test programme.

The PFT gave good results on ice, the values were very near the average of the whole range of equipment. On snow the PFT did not give reliable results, because it is too light. The weather conditions were varying quite a lot during the test week and the temperature was sometimes lower than –20 °C, but there were no difficulties with the PFT.

The C-trip seemed to be sensitive to some variables. For example old tyres gave quite often higher friction values than new tyres and it did not depend on whether there were studs on the tyres or not.

7. Activities during the winter 2000-01

7.1 Friction measurements

Because there was a doubt not to have measured the friction at the right moment during the winter 1999-2000, some changes were made to the procedure. The weather centre of FinnRA alarmed immediately when the salting was needed. That was supposed to be the right moment to measure the friction too.

In many cases the friction values of all test sections were high no matter if the road was wet or dry. Sometimes the snow had spoiled everything. When the sections were covered with snow, the friction values were equal. Never had a single test section been covered with ice and it seemed that there had been a second winter without any significant results. It may be that the icing phenomenon is quite rare and there may be winters without the risk of sudden icing on exclay insulated roads.

The work will continue by determining through the huge amount of data from the weather stations if the measurements have been done at the right moment or not.

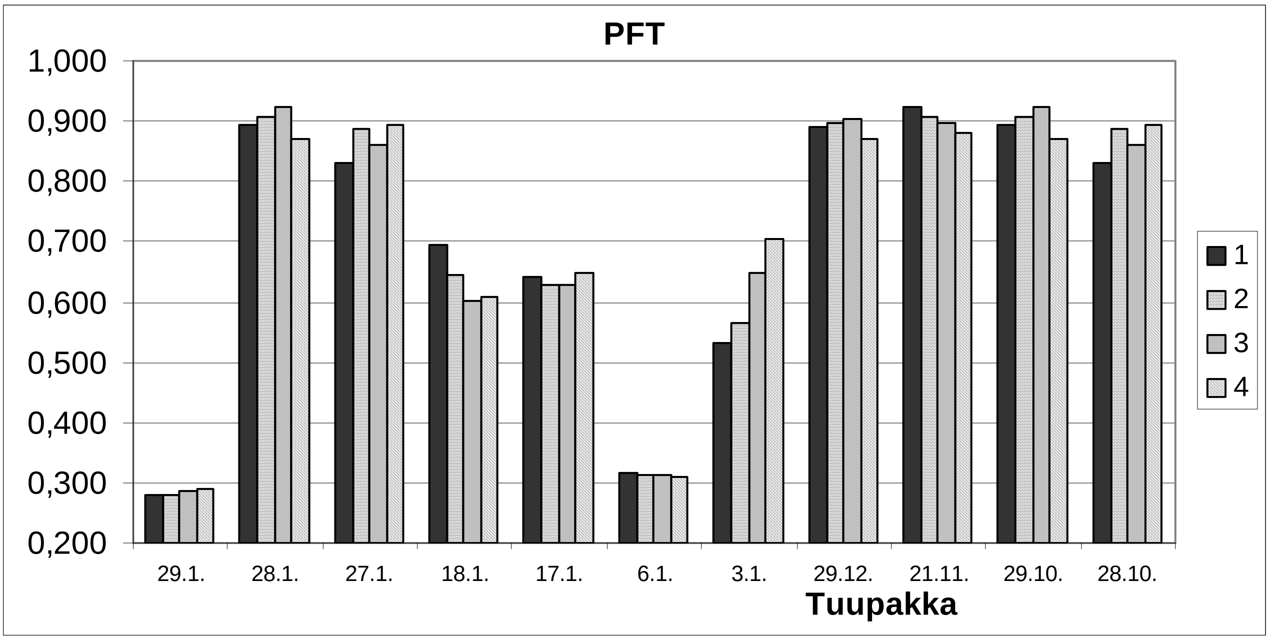

Figure 2a. PFT FRICTION MEASUREMENTS, average results (number 1: no exclay, 2: 0,7m layers over exclay, 3: 0,5m and 4: 0,35m)

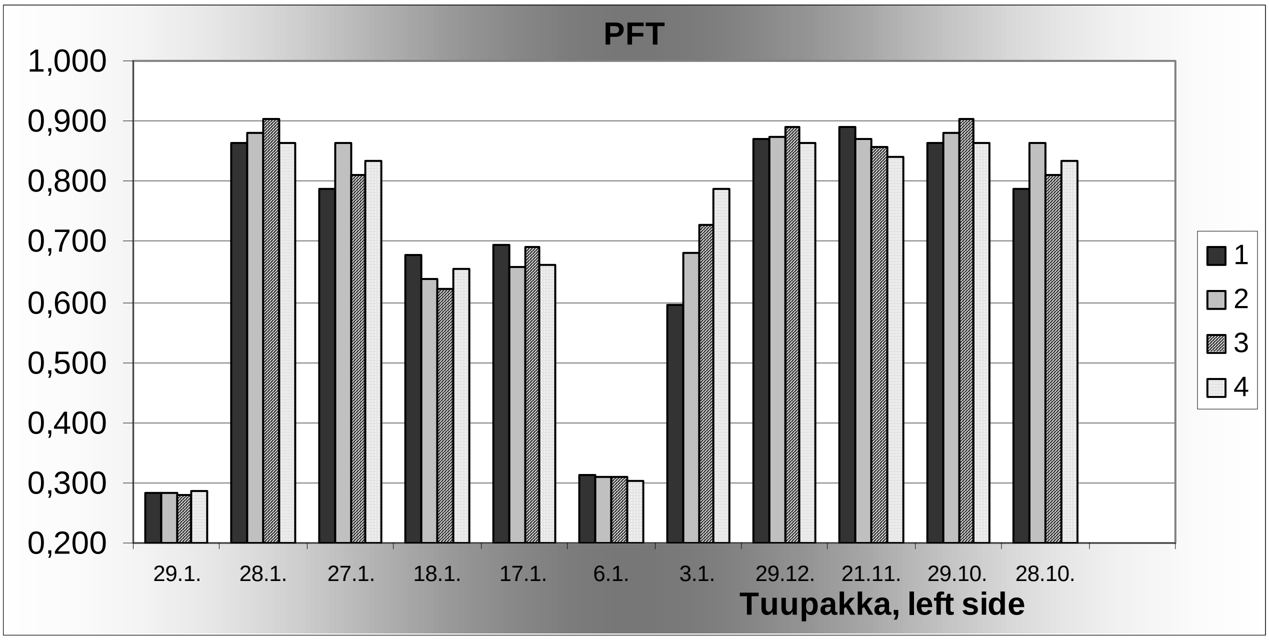

Figure 2b. PFT FRICTION MEASUREMENTS, left side of the road

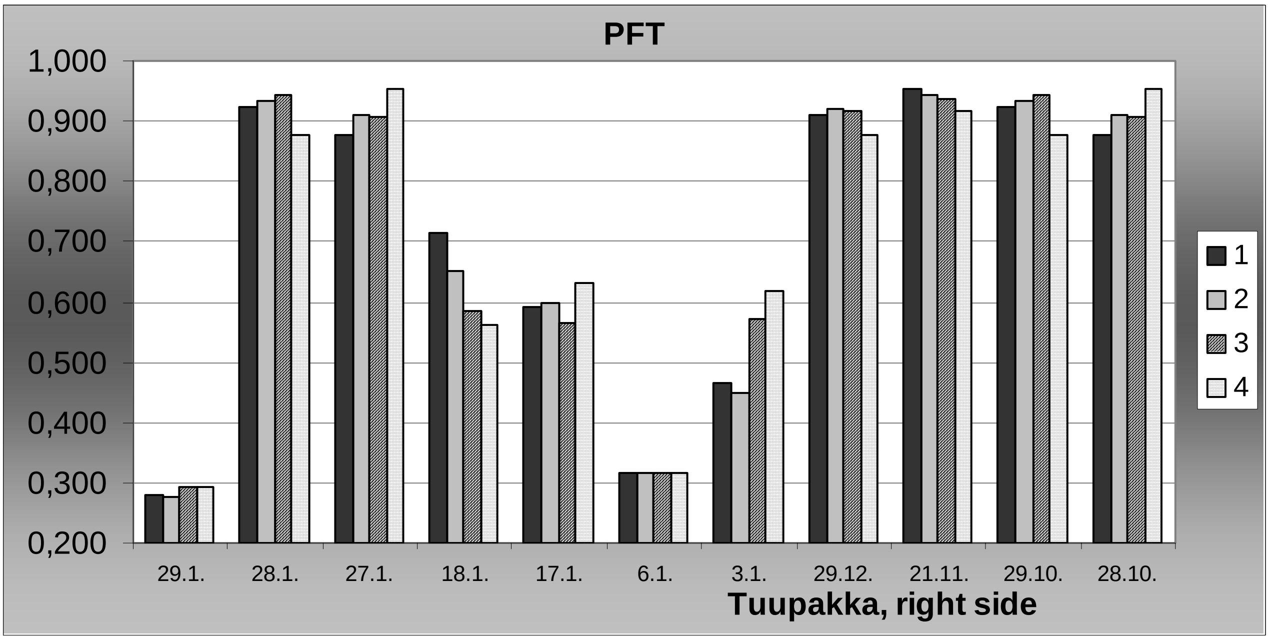

Figure 2c. PFT FRICTION MEASUREMENTS, right side of the road

7.2 Temperature measurements

Four test structures were instrumented with temperature sensors (thermo couples) after the pavement construction using drilling machinery. The installation depths of the temperature sensors are: air (2 m over ground surface), surface of AC (=20 mm), 70 mm, 150 mm, 350 mm, 650 mm and 1500 mm. To the depths of 20 and 70 mm two sensors are installed in every test structure. A cabinet for measuring system (modem, GSM and AC/DC plug) was attached to a column beside the bus ramp.

The system measures the temperature of the thermo couples with adjusted intervals (1.5…3 h) and sends the measured data as a text message to the server of the phone operator, which transforms the text message to an e-mail message. The e-mail message is sent to a PC located in SCC Viatek Ltd where the data is handled and saved. An example of data from period 1.1.2001…31.1.2001 is presented in figure 3 which shows the air temperature and the surface temperature of a structure without exclay and a structure where there are only 350 mm layers over exclay. At this time of the winter the temperature difference between those two structures is minor.

Other weather conditions than the temperature (dew point, relative humidity, air pressure, wind speed, wind direction and cloud height) are collected from Vaisala measuring station located 1.8 km from Tuupakka test site (those measuring results in internet address: http://www.vaisala.com/weather).

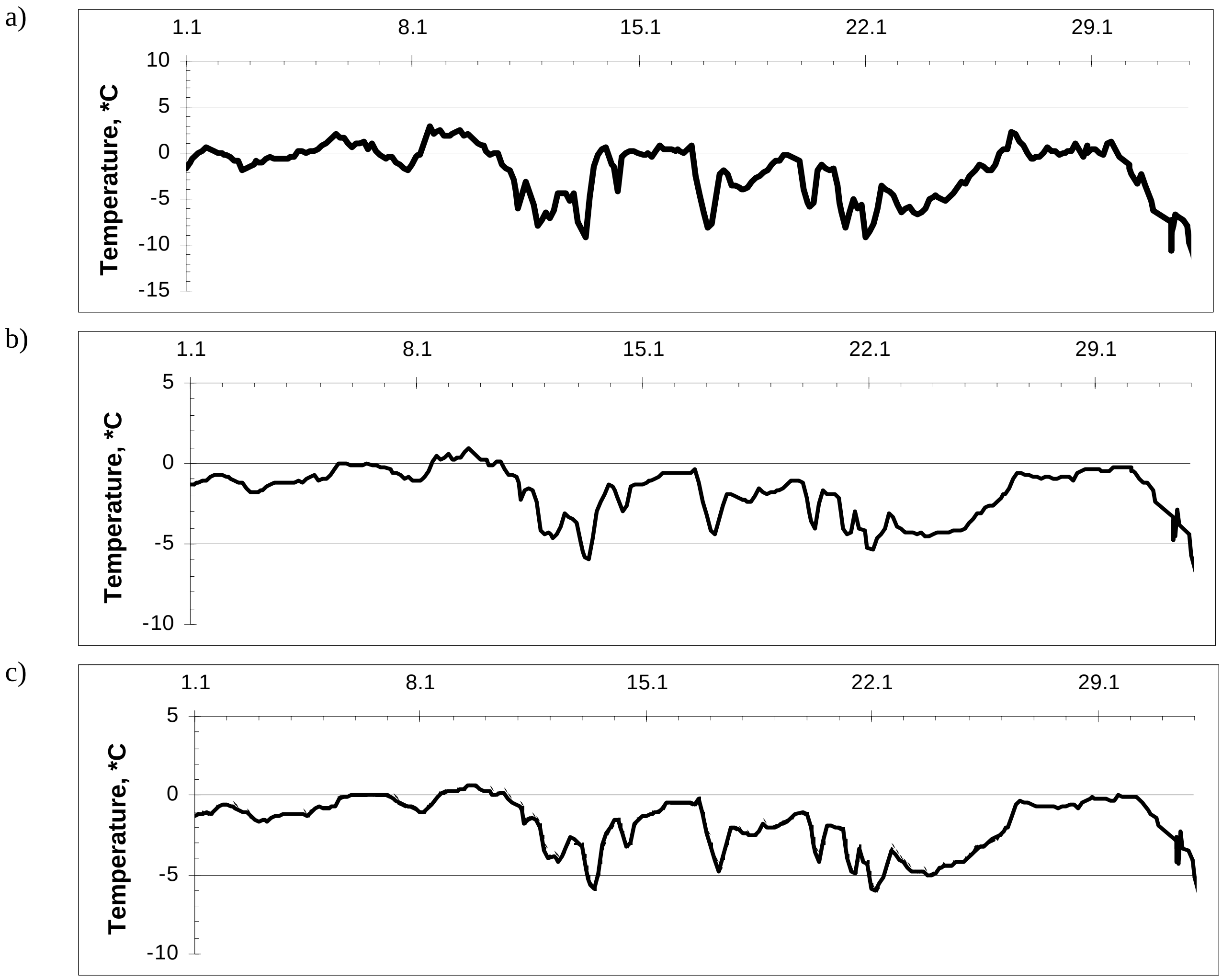

Figure 3. Tuupakka site 1.1.2001…31.1.2001. a) Measured air temperature at level 2,0 m over ground surface. Measured temperature of the surface of AC-layer: b) no exclay and c) 350 mm layers over exclay.

8. Conclusions

The target of the study was to find a sufficient depth for the insulation layer without any risk of unexpected slipperiness. From the theoretical point of view it is clear that during an average winter there are days, when an insulated road should be covered with ice, but other roads not. Now it seems that in reality there may be winters without that kind of risk. Also effective salting alarmed by a well-equiped weather centre may equalise the road network and no unexpected slipperiness will occur.

In every case, more data is needed to be sure that the insulation will not have a fatal effect on traffic safety. Because of the similarity of climate conditions and construction materials the research results and experiences of each country can be utilised in all the countries (Finland, Sweden and Norway) involved in the research.

Literature

Malmivuo Mikko, Kitkamittauslaitteiden vertailututkimus 2000, Tielaitoksen selvityksiä, Tiehallinto, Helsinki 2000, Not published yet

Measuring of Friction Temperature Modelling Test Structures, Report II, Exclay Internordic Geoproject, Finnish Activities 1999-2000, 22.6.2000, Espoo