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External thermal and moisture insulation of outer basement wall

RWSC administration building
Hovedgaden 501, DK-2640 Hedehusene

Performed for:
Rockwool International
Hovedgaden 584
DK-2640 Hedehusene

Performed by:
P.F. Collet

Taastrup, 27 March 2009

Project No.: 1345680
Order No.: 294475

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1. Background and purpose

1.1 Requesting party

Rockwool International A/S
Hovedgaden 584
DK-2640 Hedehusene

1.2 Object

Administration building
Hovedgaden 501, Entrance D
DK 2640 Hedehusene

1.3 Background

In 1976, the basement outer wall was insulated externally in order to improve the thermal insulation. However, the aging of the insulation has not been inspected subsequently.

As moisture and thermal insulation of basement outer walls have become more generally used, it has grown important to evaluate the ageing of this 32-year old insulation in order to obtain a reference with a certain age.

For that reason, Danish Technological Institute working together with Rockwool International A/S has examined moisture and stability properties of the old thermal insulation.

According to the old records, the density should be approximately 90 kg/m^3 and the insulation thickness approximately 75 mm.

1.4 Purpose

The purpose of the assignment is first and foremost to estimate the moisturising of the insulation and if possible the compression of the fitted insulation in order to evaluate whether noticeable deteriorations of the insulation and its properties have taken place.

1.5 Data and information

The requesting party has stated the following:

- The insulation was fitted in 1976.
- The insulation is made up of 75 mm slab batts, Rockwool Pladebatts, with a density of 90 kg/m^3.
- There is a French drain leading to a plain sump without pump, probably located 300 mm below the basement floor.

2. Summary

2.1 Scope of task

The following survey has been performed:

After digging a hole approximately 1700 mm deep, two relatively large samples of the insulation were taken, and the moisture contents and the permanent compression of the insulation were measured.

Data loggers were fitted to record temperature and moisture in sampling areas that were moist as well as in a dry area in order to evaluate the fundamental influence of insulation on the drying of the outer wall of a basement.

2.2 Results

Fitting of data loggers and recording data

Fitting of data loggers in Rockwool batts
Having taken the two samples to determine the compression and the water absorption, three sampling areas were established in the mineral wool.

The sampling holes were cut open to 600 x 900 mm. The 75 mm thick insulation removed, which had been pasted up with bitumen, was replaced by 200 mm replacement insulation.

The new insulation was cut into shape and hollowed out so that a data logger could be fitted against the remains of the bitumen; the second data logger was fitted in the outer part of the insulation towards the soil.

The insulation was hollowed out from the inner, warm side so that the outside was intact, and so that the holes for the data loggers were filled out with insulation.

Thus, the insulation was relatively flawless except for the hole where the data logger was fitted.

This way, counting from the warm side, one data logger was fitted directly upon the concrete element, and the other data logger was fitted approximately 20 mm from the outside (the soil side) enabling the determination of the temperature and moisture gradients across the insulation and monitoring the drying of the dish cloths (the moist foundation).

Sampling area 1, dry area, Rockwool Erhverv
The sampling area was filled out with 200 mm Rockwool Erhverv batts directly on the dry and partially bitumen treated (old paste glue) concrete element. The new insulation was fitted closely to the existing 75 mm thick insulation.

Sampling area 2, wet area, Rockwool Erhverv
This sampling area was set up like sampling area 1 except that between the insulation and the concrete element a twice folded (four layers) wet dish cloth (approximately 500 g water corresponding to 8 kg water per m^2) was placed to simulate a wet foundation.

Sampling area 3, wet area
This sampling area was set up like sampling area 2 except that here, 200 mm polystyrene was used instead of 200 mm mineral wool.

With the data loggers placed uniformly in the insulation in each of the three sampling areas and with the same insulation thickness in each area, it was now possible to monitor the drying of the moistened dish cloths (which simulated the wet foundation) behind the polystyrene sampling area 3 and behind the Rockwool Erhverv sampling area 2 respectively and this way compare the drying of the two “wet” sampling areas with the original dry construction sampling area 1.

Recordings of the original 75 mm Rockwool Pladebatts
With the new insulation fitted, the old insulation was removed and inspected.

It was not feasible to determine the specific type of Rockwool used in the original insulation in a simple way. However, based on the samples taken, the density is calculated to be 175-200 kg per m^3 wherefore the original insulation is likely to have been Pladebatts 3.

<u>Moisturising</u>
The two insulation samples taken showed that the outer 10-15 mm of the insulation have been moisturised to 25-30 weight percent water and that the inner part (aprox. 60 – 65 mm) of insulation contained less than 1 weight percent water.

The thickness of the insulation samples taken was measured to be 72-75 mm. This means that, except for the initial compression at the initial mounting, hardly any compression has taken place during the construction’s lifetime of a good 30 years.

<u>Measurements of the drying of the sampling areas</u>
The measurements of the drying of the sampling areas were made by fitting two wireless data loggers in each sampling area such that the climate was measured innermost on the warm side of the insulation right next to the wet dish cloth and likewise outermost in the outer part of the insulation.

Measurements were logged every hour, and the drying was monitored during three months from mid December to mid March.

Sampling area 1, dry sampling hole

Except for initial variations in temperature and relative humidity due to varying influence from the open hole in the ground, the area reached fairly good equilibrium after just under one week after filling the hole and levelling ground.

The climate in the insulation stabilised at 55-60 %RH and 15-16 °C at the wall and 90-95 %RH and 8-9 °C towards the soil.

During the following two months, the variations in the climate were limited, although with changes in the recorded values that are normal for the season.

Sample area 2, wet sampling hole, Rockwool Pladebatts

Except for initial variations in temperature and relative humidity due to varying influence from the open hole in the ground, the area reached fairly good equilibrium after just under one week after filling the hole and levelling ground.

The climate in the insulation stabilised at 95-100 %RH and 15-16 °C at the wall and 95-100 %RH and 9-10 °C towards the soil.

During the following 2-3 weeks, the climate variation in the insulation was limited. Then very fast climate changes occurred, and the climate in the inner and outer part of the insulation were stabilised at the same level as for sampling area 1, the dry hole.

Sampling area 3, wet sampling hole, polystyrene

Except for initial variations in temperature and relative humidity due to varying influence from the open hole in the ground, the area reached fairly good equilibrium after just under one week after filling the hole and levelling ground.

The climate in the insulation was stabilised at 90-95 %RH and 13-14 °C at the wall and 95-100 %RH and 8-9 °C towards the soil.

During the next 3 months, the variations of the climate in the insulation were limited. However, there was a small tendency to a very slight drop in relative humidity at the basement wall.

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Documentation

3. Conclusion

External moisture and thermal insulation with Rockwool Batts
The measurements of moisturising and compression of the insulation shows that not even a span of 30-35 years lead to a noticeable and permanent compression, and that the insulation by and large remains completely dry.

In spite of a backfill of plain soil in stead of drainage gravel, as the drainage standard prescribes, the insulation is only slightly moisturised with 25-30 weight percent in the outer 10-15 mm of the insulation, and the rest of the insulation is completely dry.

Drainage of water from the earth layers down into the drains has thus taken place in the soil and in the first few mm of the insulation with a negligible penetration of the insulation.

The simulated moist wall (moist dish cloths) shows that the potential drying rate of giving off water from a very wet foundation (surface evaporation) may be as much as 20-50 kg water per m^2 per month.

Comparison of different types of external thermal and moisture insulation
When deploying external moisture and thermal insulation of various structures such as mineral wool, polystyrene, drainage sheets in various combinations and foundations of concrete and brick, one would expect that there are different modes of operation regarding evaporation rate and moistening of the insulation and drying of the foundation.

Other research (MACH calculation) shows that the maximal evaporation of wet concrete is in the order of 3000-5000 g/m^2/month, and the evaporation from a brick foundation must therefore be several times larger since a brickwall is far more open to diffusion and has a larger capillary suction rate by far than a concrete foundation.

With a presumed Z value (diffusion resistance) of 1-2 $GPa/kg/m^2s$ for 200 mm Pladebatts and 50 $GPa/kg/m^2s$ for 200 mm polystyrene insulation, a cursory calculation shows that the potential evaporation rate at a warm basement with an external Rockwool insulation will be 25-50 times larger than with a external polystyrene moisture insulation or with the use of drainage sheets or bituminisation.

Likewise, the drying through the outer surface of a foundation insulated by Rockwool Batts (not bituminised and without Platon drainage sheets) will be 2-5 times larger than the drying through the inner surface if this surface is plastered and painted in the usual way.

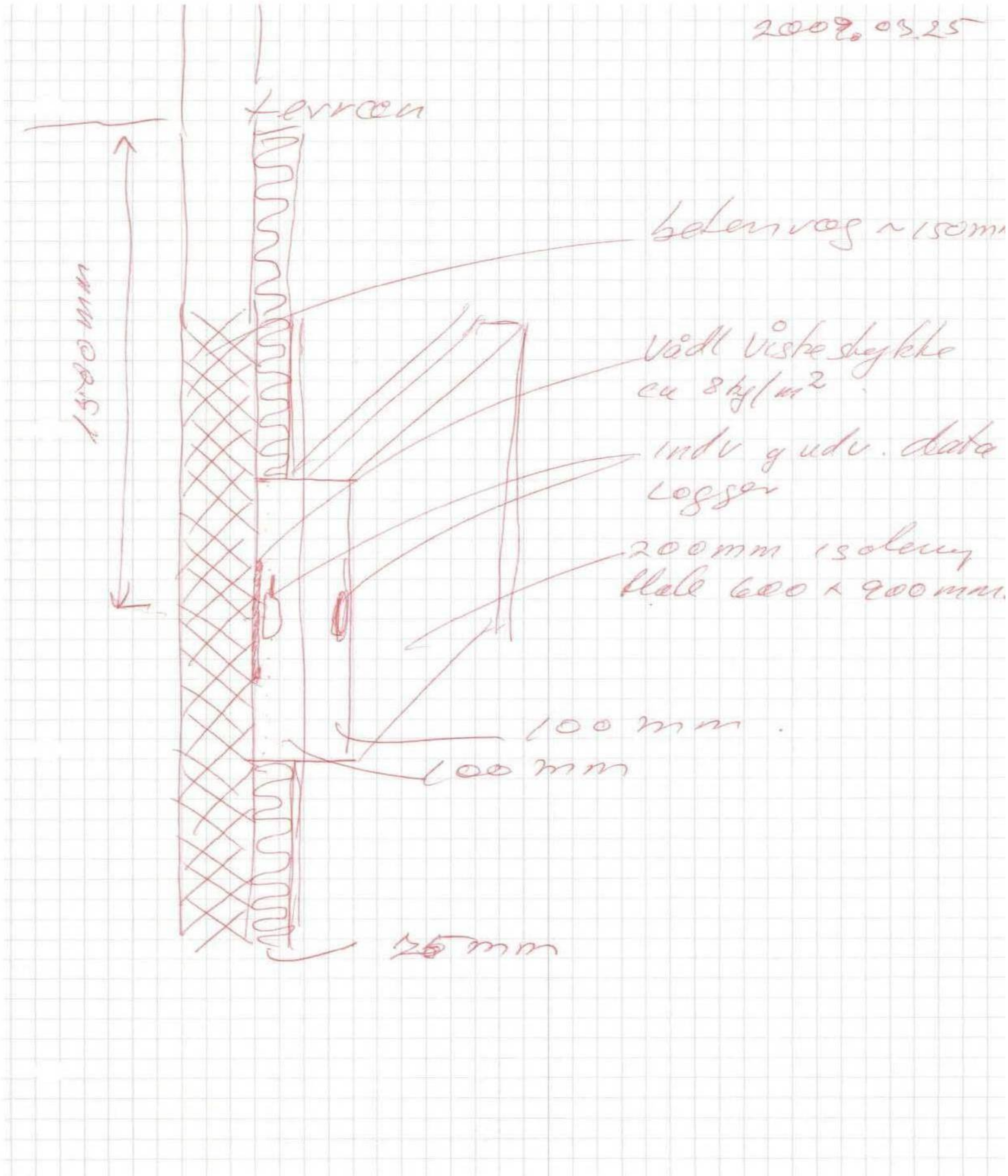
Using a polystyrene drainage slab, a drainage sheet, and bituminisation on the outside of the foundation will under all practical circumstances cause a strong reduction or elimination of the evaporation from the outside of the foundation. Thus, the combined drying rate of the foundation is reduced approximately by a factor three to five compared to an external insulation with Rockwool Batts and without the use of roughcasting, bituminisation, and Platon drainage sheets.

Using drainage sheets on the outside of an insulation with Rockwool Batts should, to a large extent, result in a moisturising of the cold side (the soil side) of the insulation because the soil pressure will lead to the drainage sheet’s being packed tightly against the insulation so that there won’t be any downward drainage.

This is totally in line with the experience showing that even if Rockwool is permeated and hydrophobic, condensation may yet take place inside the wool leading to the wool acting like a sponge, as in fact witnessed in leaky flat roofs.

Likewise, the usage of Platon drainage sheets on the cold or on the warm side of polystyrene drainage slabs is probably without interest since the evaporation from the foundation already has been eliminated under all practical circumstances by the use of polystyrene as insulation material, and the draining effect of the drainage sheet is equally without interest since the polystyrene drainage sheet takes care of the drainage.

Annex 1: Sketch of sampling points



Annex 2: Moisturising of the original 30 years old insulation

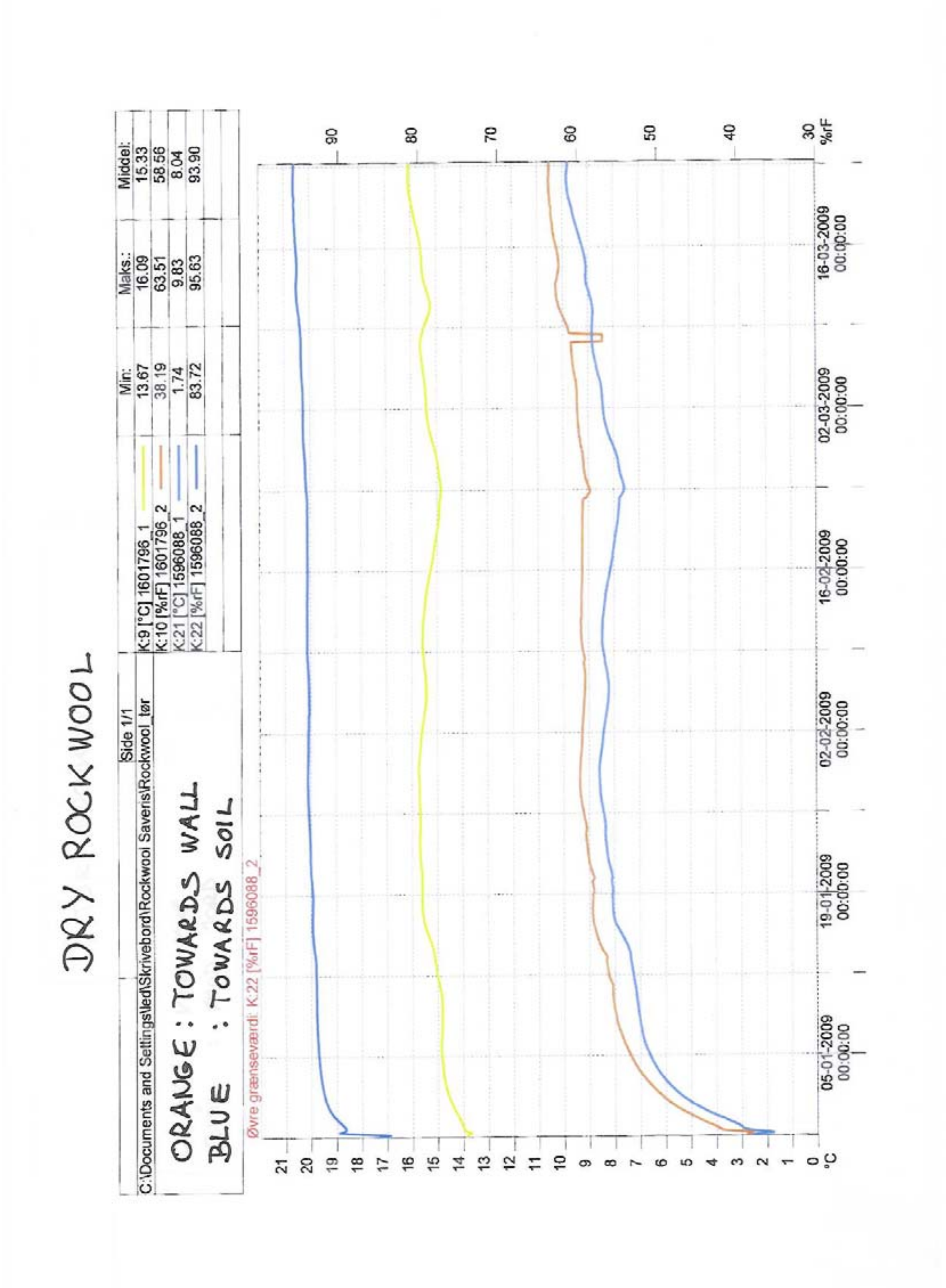
PF Collet

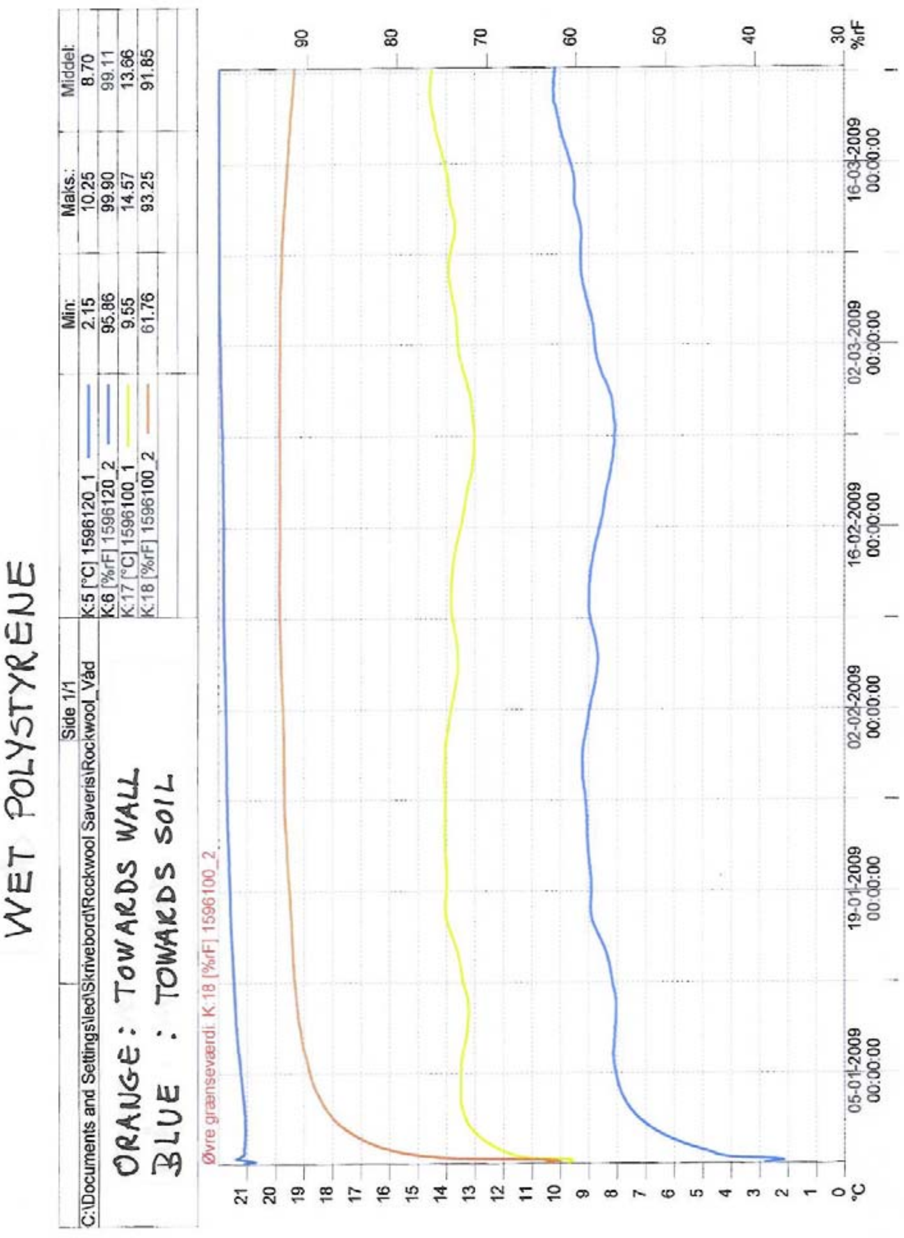
Case Number: Project Address: Rockwool 101, Entrance [redacted] D Construction: Basement wall insulation Misc.: 2009.03.25

SAMPLE	Notes to sample in bag	WET	TARE	NET WET	DRY	TARE	NET DRY	WEIGHT %	Notes to the results etc.
1	Outer 10 mm of insul. 0.9 m b.g.l.	45.4					36.0	26	Clay mud on outside
2	Middle part of insul. 0.9 m b.g.l.	70.5					70.0	<1	Feels dry when taking the sample
3	Inside part of insul. 0.9 m b.g.l.	56.5					56.5	<1	Feels dry when taking the sample
4	Outer 10 mm of insul. at 1.5 m b.g.l.	49.9					36.5	37	Clay mud on outside
5	Middle part of insul. 1.5 m b.g.l.	74.2					73.9	<1	Feels dry when taking the sample
6	Inside part of insul. 1.5 m b.g.l.	30.3					29.9	<1	Feels dry when taking the sample
7									Measured thickness of insulation app. 72-75 mm slab batts
8									
9									
10									
11									
12									

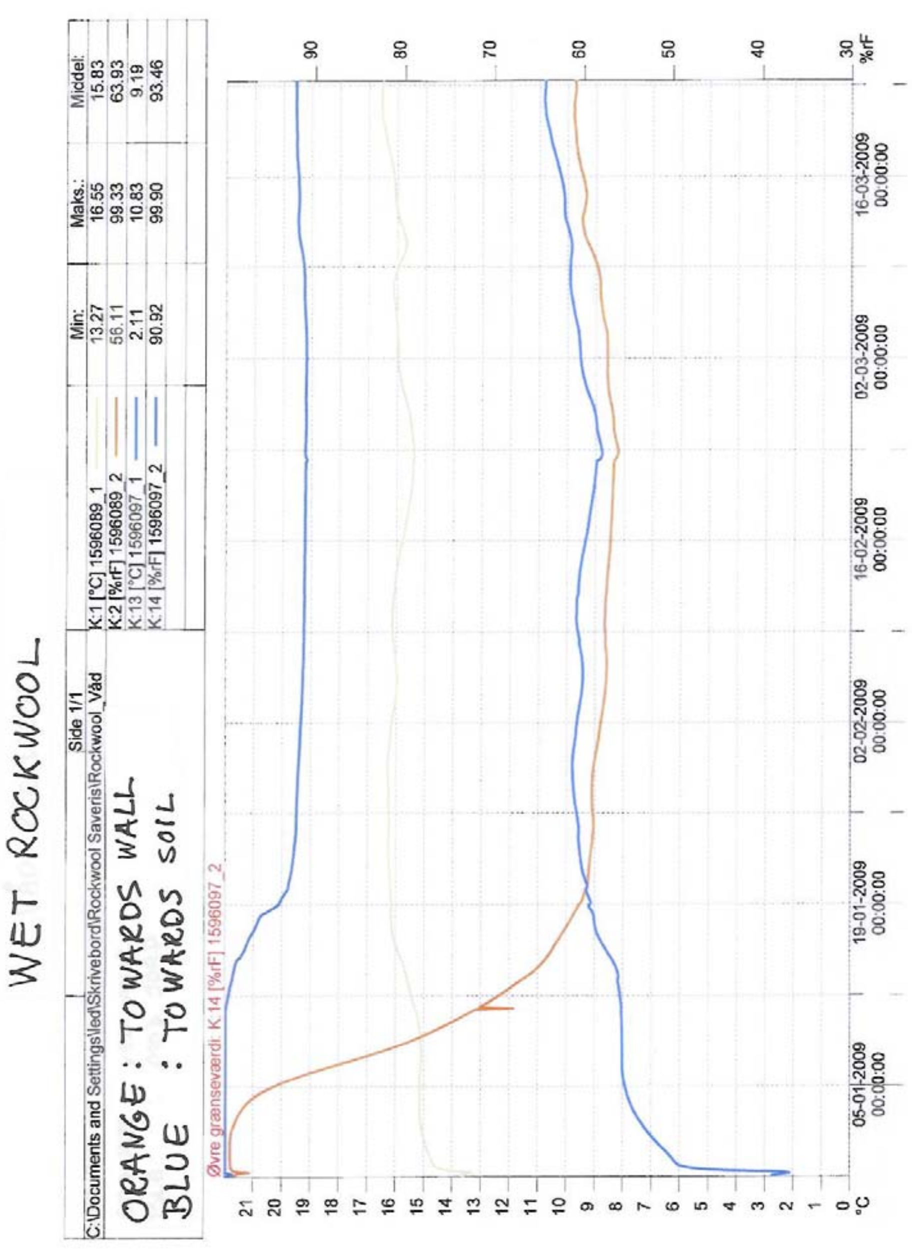
The insulation has a density of 175-200 kg/m^3
b.g.l. = below ground level

Annex 3: Recordings of temperature and humidity




WET POLYSTYRENE
ORANGE : TOWARDS WALL
BLUE : TOWARDS SOIL

27 March 2009
PFC/akr



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External thermal and moisture insulation of outer basement walls

With reference to our agreement, it is our pleasure to enclose the final report regarding external thermal and moisture insulation of outer basement walls.

As you will notice, all data agree nicely with our expectations, and they show that the outward drying potential of "our" method with Rockwool is 25-50 times larger than a more traditional procedure using one or more of the products/methods: polystyrene drainage slab, bituminisation or Platon drainage sheet.

The outer wall of a basement generally is plastered and painted when the basement is used as what might be called a warm, dry, and unauthorised dwelling. This means that by using Rockwool as external insulation, a rate of drying of the now warm foundation is achieved that is around five times greater than by using more traditional methods, which are recommended by Moisture Instruction 178.

When comparing the drying rates of the wet foundations under the original non-insulated conditions, it is to be expected that the rate of drying of the moisture and thermally insulated foundation increases by a factor five.

Sincerely yours,
Danish Technological Institute, Construction

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