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Assignment Report

Thermal conductivity of ground, Brock synthetic bases and synthetic turf

Summary

On behalf of Brock USA the Norwegian Building Research Institute (Byggforsk) has performed testing of thermal resistance and thermal conductivity on Brock underlay and different types of synthetic turf.

This report gives an overview of the tests performed and a comparison with the thermal resistance in the ground soil.

The thermal properties of thermal insulation products depend on several factors, including temperature, moisture content and convection. The thermal properties of the ground also depend on different factors as density, particle size, degree of water saturation, type of constituting the particles, whether frozen or unfrozen.

Protection against frost heave should be designed and calculated in every case.

Table 6.1 gives an example on thermal resistance for different thicknesses of ground materials equal to the thermal resistance of the synthetic turf products.

Address of the building			Built (year)
	Method Laboratorieundersøkelse	Keywords Idrettsbygg, Golv på grunnen, Varmeisolasjon, Idrettsdekke, Plast, Gummi, Varmegjennomgang, Fukt	Filename O20935-4 Rapport engelsk Brock USA - GD

1. Introduction

On behalf of Brock USA the Norwegian Building Research Institute (Byggforsk) has performed testing of thermal resistance and thermal conductivity on Brock underlay and different types of synthetic turf.

This report gives an overview of the tests performed and a comparison with the thermal resistance in the ground soil.

Byggforsk is the leading Norwegian institute of technical and sociological research and development relating to buildings and the built environment. Byggforsk is officially designated as a notified body for certification, technical approval, testing and inspection. registration no.1071.

2. Test method

The measurements are performed in accordance with ISO 8301:1991, EN 12664:2001 and EN 12667:2001 with a Heat flow meter apparatus (HFM) for one test specimen comprising 600 mm x 600 mm and symmetrically placed heat flow meters with 300 mm x 300 mm measuring area. The heat flow is directed vertically downwards.

The tests were performed on both dry and wet material with mean specimen temperature 10 °C and a temperature difference over the specimen of approximately 20 °C.

3. Test material

The thermal resistance has been measured for two different types of Brock underlay and four different types of synthetic turfs. The samples were dispatched directly from the manufacturer. Data about the specimens receive date and number is given in the test reports O20935-1, O20935-2 and O20935-3.

An overview of the test specimens and the tests results are given in table 3.1. The arrangement for spraying the test specimen with water is shown in figure 3.1.

Figure 3.1 Arrangement for spraying the test specimen with water

4. Test result

A summary of the thermal measurements presented in the reports O20935-1, O20935-2 and O20935-3 are given in table 4.1.

Table 4.1
Summery of the thermal measurements performed on Brock underlay and synthetic turf

Spec. No.	Description Infill	Thickness mm	Preparation	Moisture content kg/kg	Thermal resistance	Equivalent thermal conductivity
1	Brock Shock Pad	13	Dry 23 °C in minimum 6h	0.02	0.33	0.039
2	Brock Shock Pad	13	Sprayed with water 3 l per minute in 1 hour Drained for 1 hour	0.70	0.24	0.054
3	Brock Performance Base	23	Dry 23 °C in minimum 6h	0.01	0.56	0.041
4	Brock Performance Base	23	Sprayed with water 3 l per minute in 1 hour Drained for 1 hour	0.29	0.47	0.049
5	Brock Performance Base	23	Immersed in water for 3 hours Drained for 1 hour	0.59	0.42	0.055
6	Synthetic turf Pile height 40 mm with infill 1st layer 10 mm sand 2nd layer 10 mm rubber	-	Sprayed with water 3 l per minute in 10 minutes Drained for 3 hours	0.23	0.11	0.25
7	Synthetic turf Pile height 60 mm with infill 1st layer 13 mm sand 2nd layer 13 mm rubber	-	Sprayed with water 3 l per minute in 10 minutes Drained for 3 hours	0.21	0.18	0.26
8	Synthetic turf Pile height 24 mm with infill One layer of sand 10.44 kg/60 cm^2	-	Sprayed with water 3 l per minute in 10 minutes Drained for 3 hours	0.21	0.037	0.64
9	Synthetic turf Pile height 65 mm with infill 1st layer 5.94 kg/60 cm^2 sand 2nd layer 5.94 kg/60 cm^2 rubber	-	Sprayed with water 3 l per minute in 10 minutes Drained for 3 hours	0.18	0.25	0.19

5. Heat transfer via ground

Thermal resistance and thermal conductivity is defined in EN ISO 7345. An outline from EN ISO 7345 is given in table 4.1.

Table 5.1
Physical quantities and definitions

Quantity and definition	Symbol	Unit
Thermal resistance Temperature difference divided by the density of heat flow rate in the steady state condition	R	m^2K/W
Thermal conductivity Quantity defined by the relation q = -λ grad T, (Heat flow rate per temperature difference)	λ	W/mK
For a plane layer with thickness d and when the thermal conductivity is constant or linear with the temperature, we have the relation between thermal resistance and thermal conductivity: R = λ / d		

The thermal properties, thermal resistance and thermal conductivity, is used for heat transfer calculations in building constructions and heat transfer via ground. The thermal properties of thermal insulation products depend on several factors, including temperature, moisture content and convection. The thermal properties of the ground also depend on different factors as density, particle size, degree of water saturation, type of constituting the particles, whether frozen or unfrozen.

Values of the properties of frost insulation and the ground used for heat transfer calculations including measured values, should be representative of the ground in the vicinity of the construction and over the period of time which the calculations refers.

Thermal conductivity for various types of unfrozen ground is presented in table 3.2.

Table 5.2
Thermal conductivity of ground

Ground Frost insulation	Ref.	Dry density kg/m^3	Moisture content kg/kg	Degree of saturation %	Thermal conductivity W/mK	Representative value W/mK
Silt Clay	[1])	1400-1800 1200-1600	0.10-0.30 0.20-0.40	70-100 80-100	1.0-2.0 0.9-1.4	1.5
Dry sand Wet sand	[1])	1700-2000 1700-2100	0.04-0.12 0.10-0.18	20-60 85-100	1.1-2.2 1.5-2.7	1.1 [4])
Gravel	[2])	1800-2001	0.02-0.06	15-40	1.0-2.0	1.0 [4])
Crushed stone	[2])	1500-1800	0.01-0.04	10-30	0.7-1.5	0.7 [4])
Crushed stone	[3])	1500	-	-	0.7	0.7
Expanded clay Aggregate (Lava)	[2])	-	Frost insulation	-	0.2	0.2
Expanded clay Aggregate (Lava)	[3])	300-450	Dry Frost insulation	-	0.11 0.15	0.15 [4])
Rock	[1])	2000-3000	<0.03	-	2.5-4.5	3.5

[1]) *ISO 13370:1998*
[2]) *Frost action in soils, The Royal Council for Scientific and Industrial Research and the Public Roads Administration's Committee, ISBN 82-7207-007-3.*
[3]) *NS 3031:1987*
[4]) *Design values used in the comparison example showed in table 6.1*

6. Comparison

Constructions must be designed to avoid damage resulting from frost heave. Frost-susceptible soil has to be insulated or replaced with non frost-susceptible soil. Protection against frost heave should be designed and calculated in every case.

The Brock underlay and the synthetic turf will be a part of the frost insulation and can in several cases replace some of the soil. Table 6.1 gives an example on thermal resistance for different thicknesses of ground materials equal to the thermal resistance of the synthetic turf products. In the example the thermal conductivity of Brock Shock Pad and Brock Performance Base is set to 0.5 W/mK based on the measurements on wet material.

Table 6.1
Example showing the thickness in m, of the ground or frost insulating layer that is equal to the thermal insulation of the product. The product can replace approximately the given thickness as a frost insulating layer

				Thickness in m of the ground or frost insulation layer that is equal to the thermal resistance of the product			
Product	Thickness mm	R m^2K/W	λ W/mK	Sand λ=1.1 W/mK	Gravel λ=1.0 W/mK	Crushed stone λ=0.7 W/mK	Expanded clay λ=0.15 W/mK
Brock Shock Pad	13	0.26	0.05	0.286	0.260	0.182	0.039
Brock Performance Base	23	0.46	0.05	0.506	0.460	0.322	0.069
Synthetic turf pile height 40 mm	-	0.11	0.25	0.121	0.110	0.077	0.017
Synthetic turf pile height 60 mm	-	0.18	0.26	0.198	0.180	0.126	0.027
Synthetic turf pile height 24 mm	-	0.037	0.25	0.041	0.037	0.026	0.006
Synthetic turf pile height 65 mm	-	0.64	0.19	0.275	0.250	0.175	0.038

7. Conclusion

The thermal properties of thermal insulation products depend on several factors, including temperature, moisture content and convection. The thermal properties of the ground also depend on different factors as density, particle size, degree of water saturation, type of constituting the particles, whether frozen or unfrozen.

Protection against frost heave should be designed and calculated in every case.

Table 6.1 gives an example on thermal resistance for different thicknesses of ground materials equal to the thermal resistance of the synthetic turf products.

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