EFFICIENCY OF FROST INSULATION TO PROTECT A FOUNDATION

1. Introduction

A case study shows how the program BISTRA can be used to evaluate the efficiency of frost insulation protecting a foundation.

2. Data

BISTRA data foundation.bst / VOLTRA data foundation_frost_V.vtr

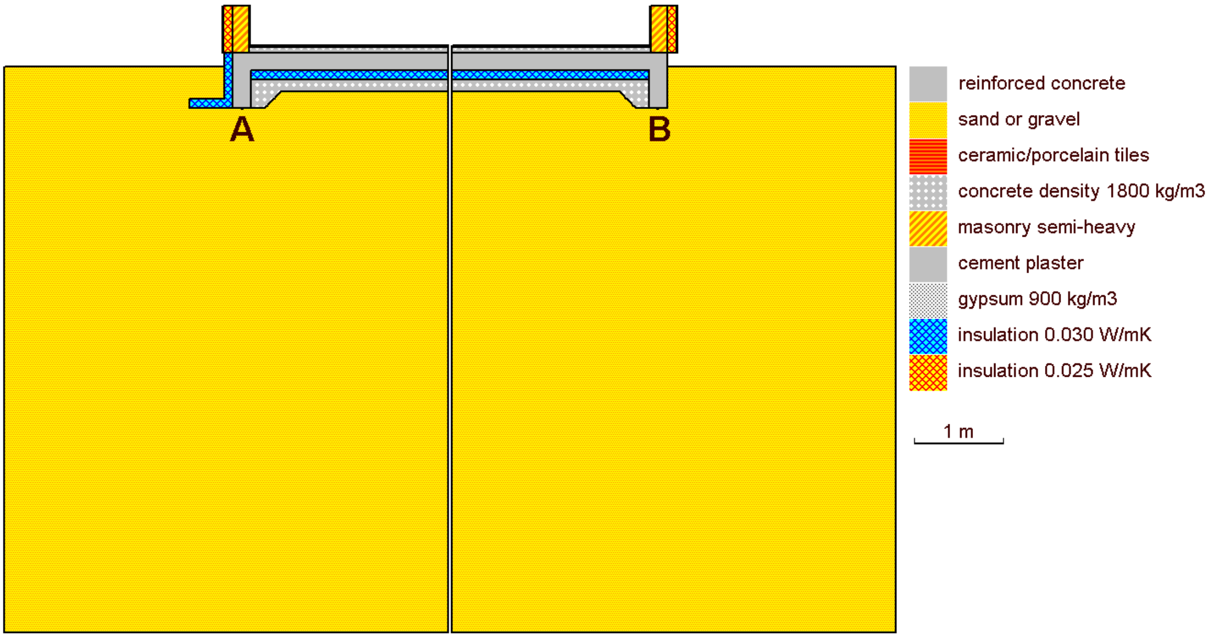


Figure 1: cross section through a foundation with (left) and without (right) frost insulation

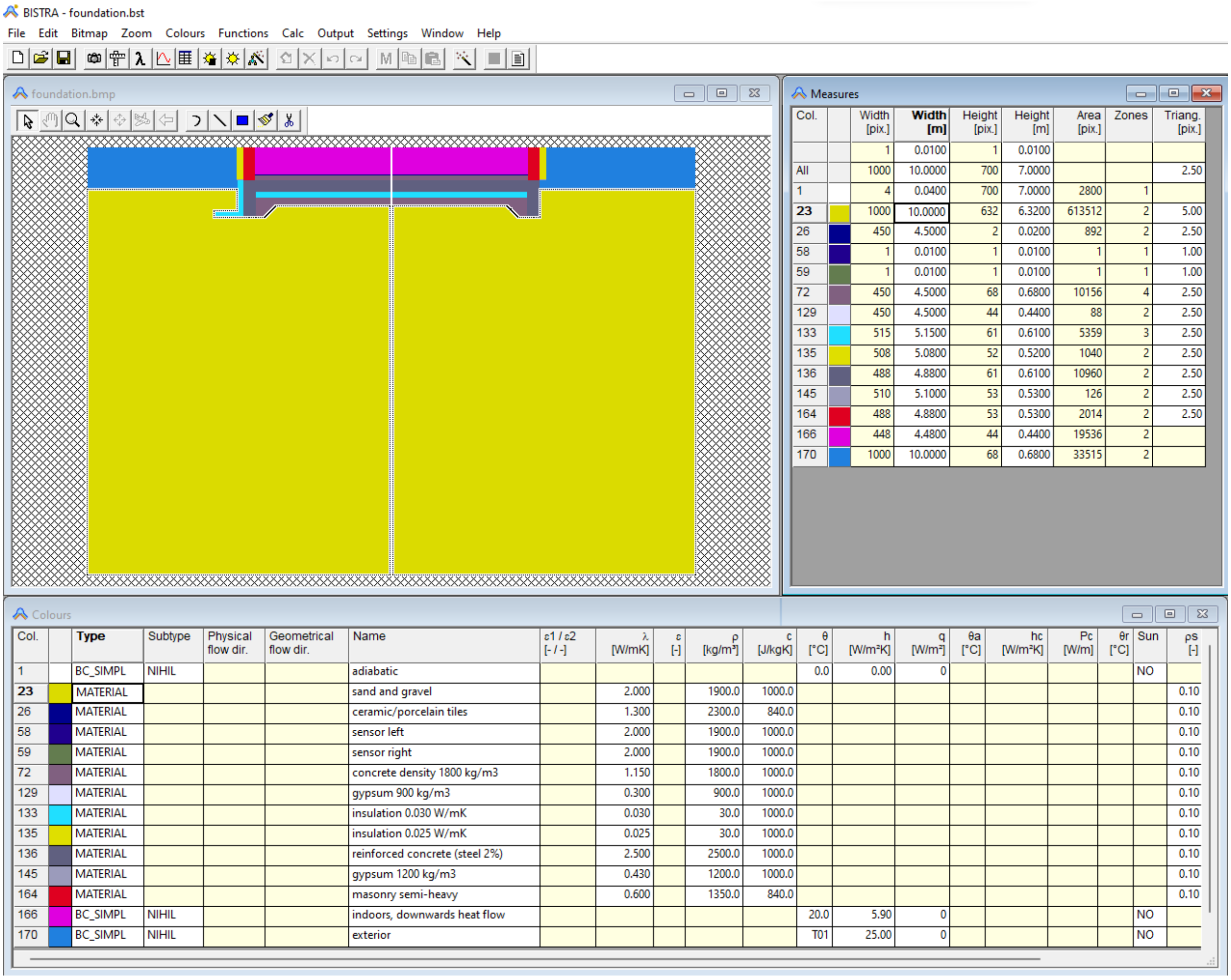
The temperature course under two foundations, one with and the other without frost insulation (Figure 1), is simulated for the climate of Warsaw. It can be expected that the thermal inertia of the large ground massive is important and therefore a transient analysis is done using the program BISTRA. Both cases are simulated together. This is done applying an adiabatic boundary condition in the center.

The file foundation.bst contains the complete data in BISTRA format. The major data part is given in Figure 2. We will discuss here some data highlights only.

- Material properties were taken from ISO 10456[1]
- For the external temperature, daily mean values for Warszawa (Figure 4) were used. The function was derived from hourly temperature values during a reference year.
- The following calculation parameters are defined:
  - time step = 1 day
  - start-up calculation duration = 1095 days = 3 year
  - calculation duration = 365 days = 1 year
  - start day number = day 91 (1 April)

The 3 year start-up time is required because of the important thermal inertia. The start date (1 April) is chosen because on that day, the outdoor temperature is about the yearly mean temperature.

- To register the temperature course in the points A and B (Figure 1), 2 bitmap pixels are used (Figure 2, colours 58 and 59). Through the Report Definition window the temperatures in these sensors will be registered in an output text file that can be processed using a spreadsheet program.



Col.	Width [pix.]	Width [m]	Height [pix.]	Height [m]	Area [pix.]	Zones	Triang. [pix.]
	1	0.0100	1	0.0100			
All	1000	10.0000	700	7.0000			2.50
1	4	0.0400	700	7.0000	2800	1	
23	1000	10.0000	632	6.3200	613512	2	5.00
26	450	4.5000	2	0.0200	892	2	2.50
58	1	0.0100	1	0.0100	1	1	1.00
59	1	0.0100	1	0.0100	1	1	1.00
72	450	4.5000	68	0.6800	10156	4	2.50
129	450	4.5000	44	0.4400	88	2	2.50
133	515	5.1500	61	0.6100	5359	3	2.50
135	508	5.0800	52	0.5200	1040	2	2.50
136	488	4.8800	61	0.6100	10960	2	2.50
145	510	5.1000	53	0.5300	126	2	2.50
164	488	4.8800	53	0.5300	2014	2	2.50
166	448	4.4800	44	0.4400	19536	2	
170	1000	10.0000	68	0.6800	33515	2	

Col.	Type	Subtype	Physical flow dir.	Geometrical flow dir.	Name	ε1 / ε2 [- / -]	λ [W/mK]	ε [-]	ρ [kg/m³]	c [J/kgK]	θ [°C]	h [W/m²K]	q [W/m²]	θa [°C]	hc [W/m²K]	Pc [W/m]	θr [°C]	Sun	ρs [-]
1	BC_SIMPL	NIHIL			adiabatic						0.0	0.00	0					NO	
23	MATERIAL				sand and gravel		2.000		1900.0	1000.0									0.10
26	MATERIAL				ceramic/porcelain tiles		1.300		2300.0	840.0									0.10
58	MATERIAL				sensor left		2.000		1900.0	1000.0									0.10
59	MATERIAL				sensor right		2.000		1900.0	1000.0									0.10
72	MATERIAL				concrete density 1800 kg/m3		1.150		1800.0	1000.0									0.10
129	MATERIAL				gypsum 900 kg/m3		0.300		900.0	1000.0									0.10
133	MATERIAL				insulation 0.030 W/mK		0.030		30.0	1000.0									0.10
135	MATERIAL				insulation 0.025 W/mK		0.025		30.0	1000.0									0.10
136	MATERIAL				reinforced concrete (steel 2%)		2.500		2500.0	1000.0									0.10
145	MATERIAL				gypsum 1200 kg/m3		0.430		1200.0	1000.0									0.10
164	MATERIAL				masonry semi-heavy		0.600		1350.0	840.0									0.10
166	BC_SIMPL	NIHIL			indoors, downwards heat flow						20.0	5.90	0					NO	
170	BC_SIMPL	NIHIL			exterior						T01	25.00	0					NO	

Figure 2: BISTRA data foundation.bst

[1] ISO 10456:2007 Building materials and products -- Hygrothermal properties -- Tabulated design values and procedures for determining declared and design thermal values

3. Results

- Animation of the temperature course during 1 year: foundation.mp4.
- Temperature course on 21 January: Figure 3.
- Temperature evolution in points A and B: Figure 4 and foundation_results.xlsx.

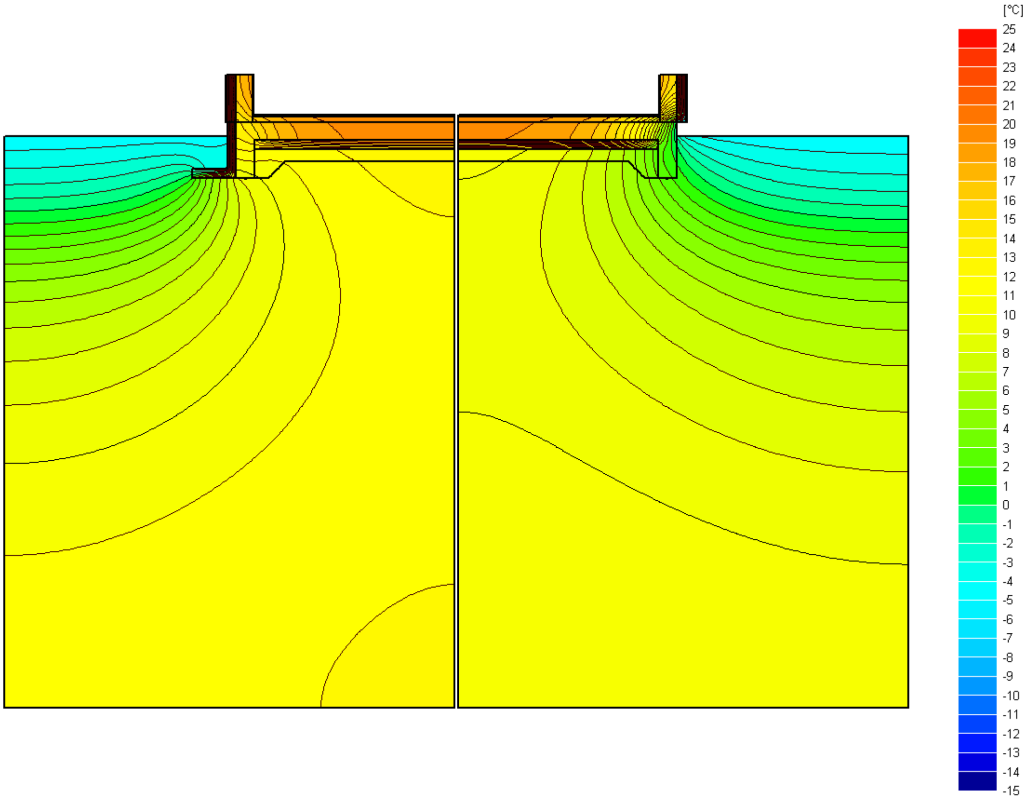


Figure 3: isotherms (increment 1 °C) on 21 January.

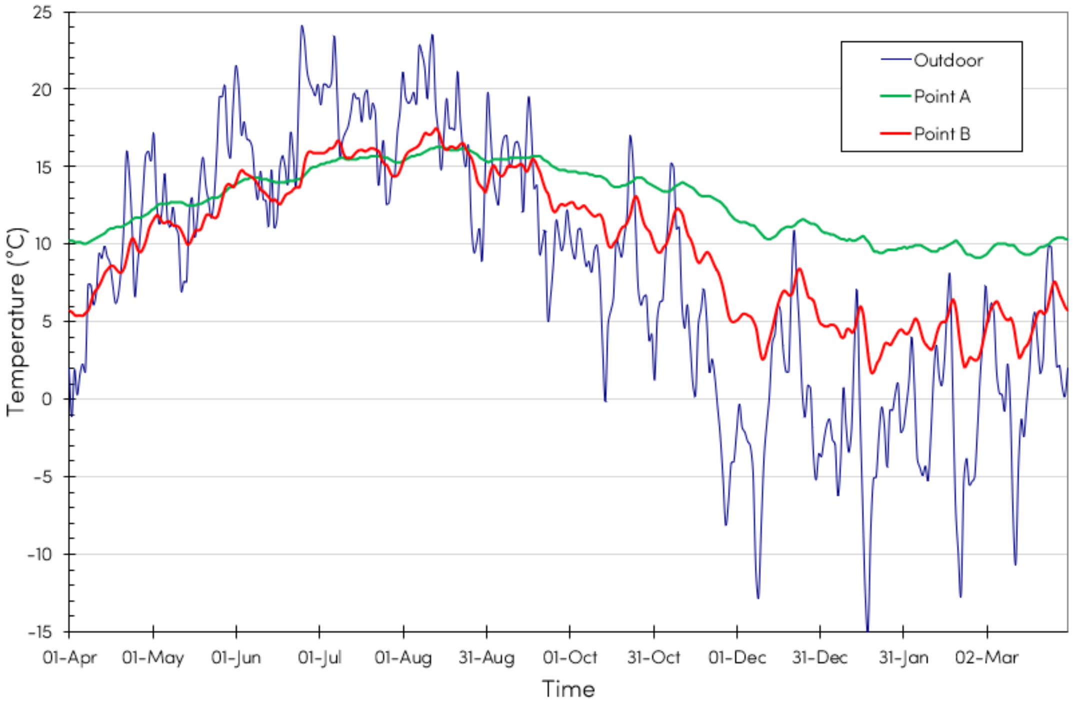


Figure 4: Daily outdoor temperature and temperature evolution in points A and B.