Clients:

Cramo Finland Oy
eGate Smart Building Innovation

eGate reference measurement of relative humidity

1 Scope and objective

The aim is to compare the relative humidity measurement results obtained through continuous monitoring using IoT technology (sensor eGATE-NSENS-HT-ENS) on two sites (site 1 and site 2) in conditions where so-called fresh borehole logging points are drilled next to the measuring points according to the new RT card 103333.

The objective of the relative humidity measurement is to learn how much the measurement results obtained through IoT technology differ from the measurement results obtained from the fresh borehole logging points.

2 Measuring instruments and methods

According to the measuring instrument manufacturer, the accuracy of the probe eGATE-NSENS-HT-ENS, which uses IoT technology, when measuring relative humidity in the temperature range of 0…50°C is ±0.8 RH% and when measuring temperature in the temperature range of 0…70°C is ±0.1°C.

Vahanen Rakennusfysiikka Oy uses humidity and temperature measuring probes manufactured by Vaisala Oyj. These probes are calibrated approximately every four months. Vaisala Oyj, the manufacturer of the measuring instruments used, recommends the probes to be calibrated at least twice a year and whenever there is reason to believe the calibration has changed. According to the measuring instrument manufacturer, the accuracy of the probe HMP40S at +20°C is ±1.5 RH% (0…90 RH%) and ±2.5 RH% (90…100 RH%). The accuracy of temperature measurement is ±0.2°C. If the measuring instrument is calibrated regularly and more frequently than recommended by the manufacturer, and if the probes are always calibrated at a relative humidity of >95 RH%, the total accuracy of the probes is ±1.5 RH%.

Measuring the relative humidity of concrete by using the borehole method

The measurements were taken next to the eGate sensors used for the study and comparison. The measuring holes were bored in a concrete slab, cleaned and lined. The pipes were carefully blocked with vapour-tight Egobon sealing compound on 3 January 2022. Two borehole logging points were made for each measuring point. During the boring, sensors were installed in the measuring pipes. These sensors were allowed to stabilise for approximately 96 hours before the measurements were taken.

The indoor air conditions at the measuring points were monitored while the boreholes were stabilising (3–7 January 2022) by using the Testo 174H data logger, which measures humidity and temperature and logs the information automatically.

Inspection of the accuracy of measuring:

Total uncertainty of measurement according to RT 103333:

Sites 1 and 2, measuring points 1

- A measuring instrument intended for concrete measurement. Accuracy ±1.5 RH%, calibration under four months, and the probe-specific drift data indicate high reading stability.
- Borehole logging with a tolerance of ~1 mm, leakproof sealing.
- Space/structure in normal use or at a temperature equivalent to nearly normal conditions. There were no significant changes in conditions during the time between the boring and measuring. Underfloor heating is not in use.
- The class of total uncertainty of measurement is ±2.

Sites 1 and 2, measuring points 2

- A measuring instrument intended for concrete measurement. Accuracy ±1.5 RH%, calibration under four months, and the probe-specific drift data indicate high reading stability.
- Borehole logging with a tolerance of ~1 mm, leakproof sealing.
- The space/structure temperature is normal with a tolerance of 5°C. There were no significant changes in conditions during the time between the boring and measuring. Underfloor heating is not in use.
- The class of total uncertainty of measurement is ±3.

Classes of uncertainty of measurement: ±1, ±2, ±3, ±4, ±5 or ±6 (see RT 103333, appendix 1).

3 Results of the reference measurement

Table 1. *Site 1, humidity measurement results from measuring point MP1 on 7 January 2022, borehole logging method. In the table of results, the sensor number is the number of the probe used, t means temperature and RH means relative humidity. The table also indicates the absolute moisture content of air (abs). The measuring point conditions during the stabilisation of the boreholes (3–7 January 2022) have been specified below the table.*

Measuring point	Depth/Structure	Sensor No	t (°C)	RH (%)	abs (g/m³)
MP1	Indoor air	***Logger***	22.9	21.8	4.5
	40 mm	***B5***	24.3	90.0	19.9
	40 mm	***B6***	24.1	89.8	19.6

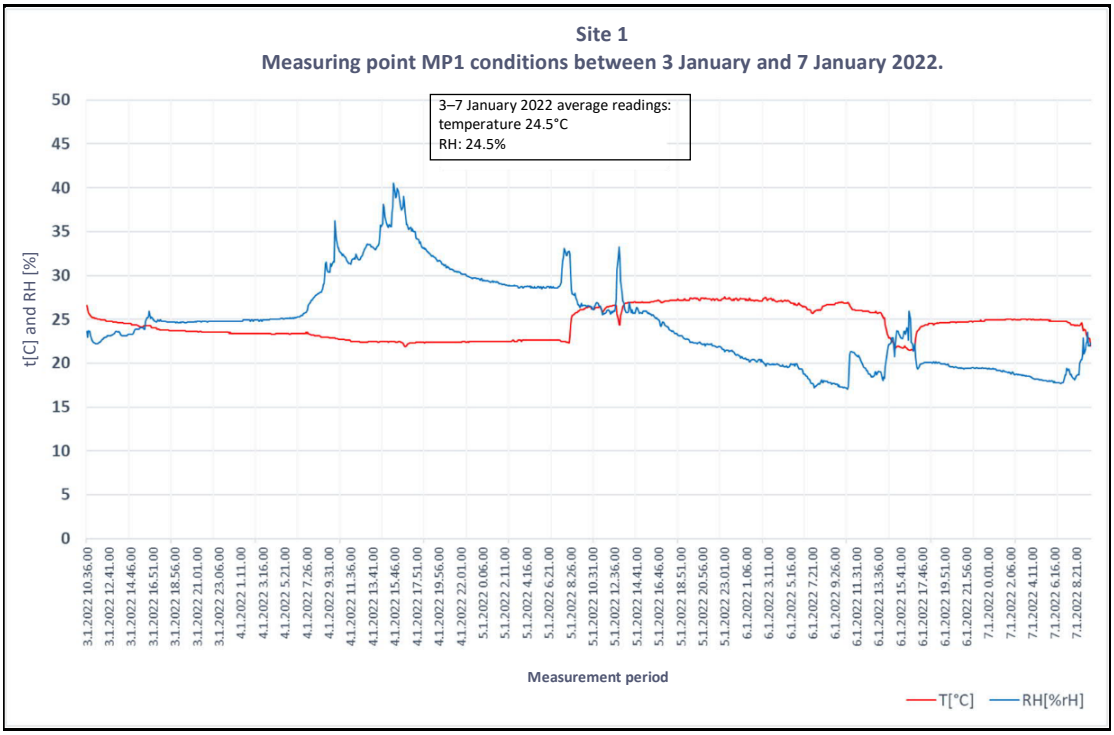


Table 2. *Site 1, humidity measurement results from measuring point MP2 on 7 January 2022, borehole logging method. In the table of results, the sensor number is the number of the probe used, t means temperature and RH means relative humidity. The table also indicates the absolute moisture content of air (abs). The measuring point conditions during the stabilisation of the boreholes (3–7 January 2022) have been specified below the table.*

Measuring point	Depth/Structure	Sensor No	t (°C)	RH (%)	abs (g/m³)
MP2	Indoor air	***Logger***	15.5	22.7	3.0
	40 mm	***A5***	14.0	86.6	10.5
	40 mm	***A6***	14.0	85.4	10.3

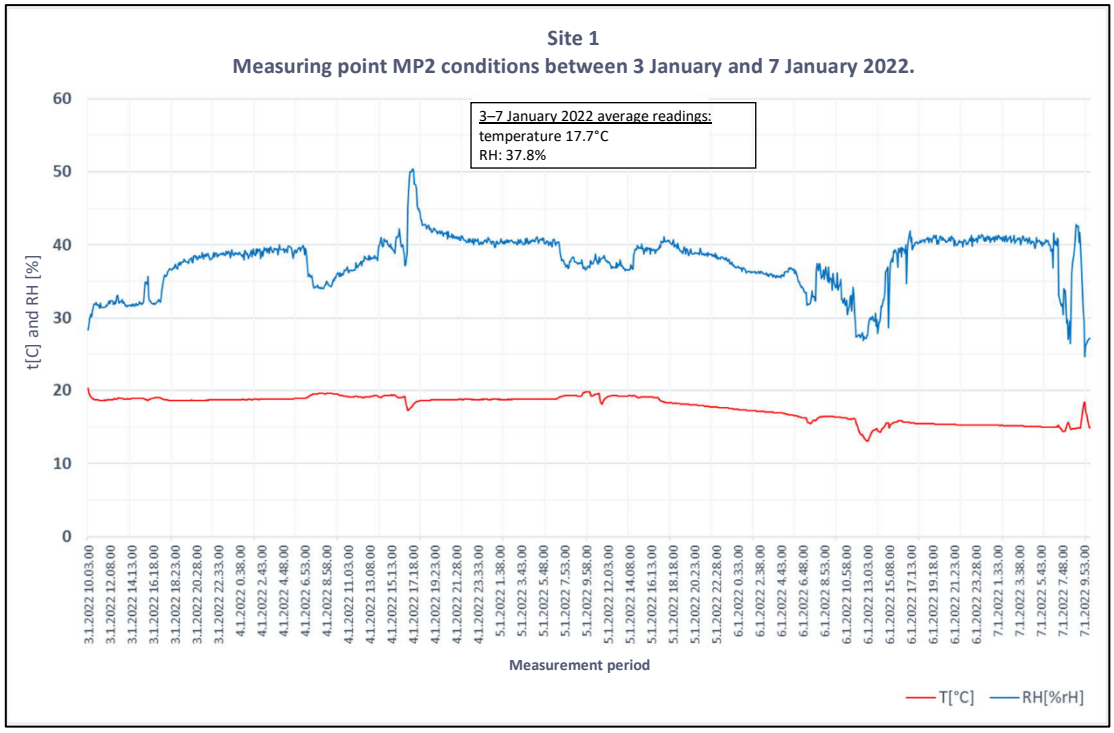


Table 3. *Site 2, humidity measurement results from measuring point MP1 on 7 January 2022, borehole logging method. In the table of results, the sensor number is the number of the probe used, t means temperature and RH means relative humidity. The table also indicates the absolute moisture content of air (abs). The measuring point conditions during the stabilisation of the boreholes (3–7 January 2022) have been specified below the table.*

Measuring point	Depth/Structure	Sensor No	t (°C)	RH (%)	abs (g/m^3)
MP1	Indoor air	***C10***	23.2	21.0	4.4
	40 mm	***B7***	23.1	91.9	19.0
	40 mm	***B8***	23.1	93.1	19.2

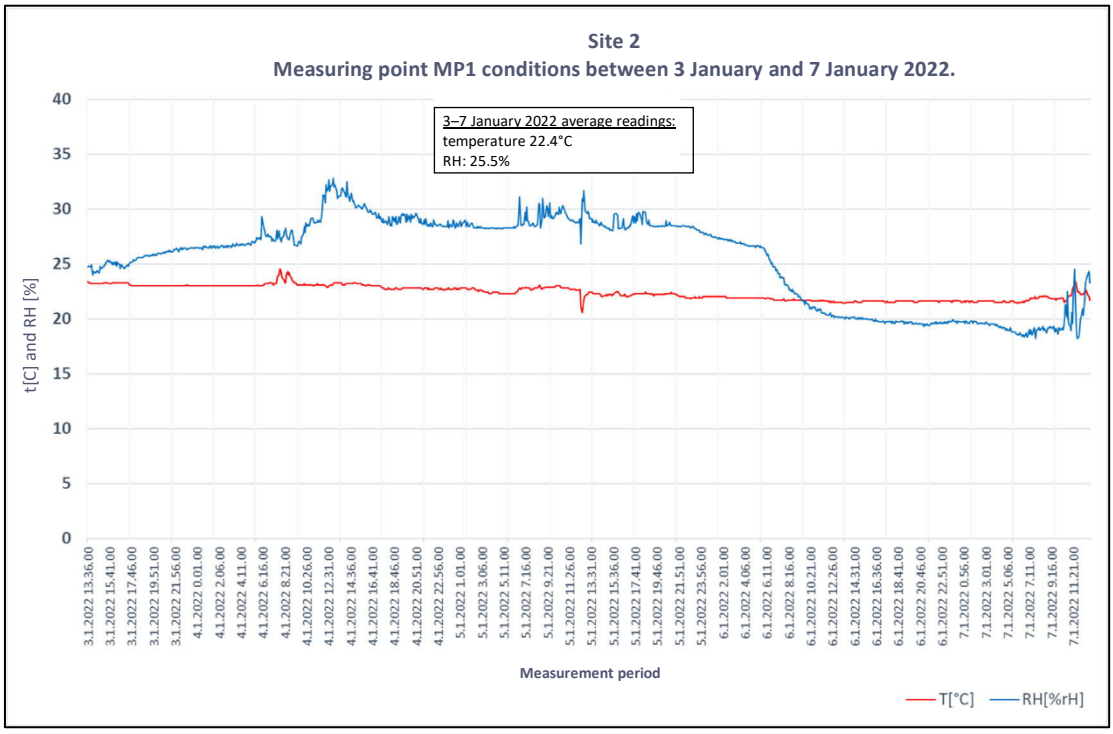


Table 4. *Site 2, humidity measurement results from measuring point MP2 on 7 January 2022, borehole logging method. In the table of results, the sensor number is the number of the probe used, t means temperature and RH means relative humidity. The table also indicates the absolute moisture content of air (abs). The measuring point conditions during the stabilisation of the boreholes (3–7 January 2022) have been specified below the table.*

Measuring point	Depth/Structure	Sensor No	t (°C)	RH (%)	abs (g/m³)
MP2	Indoor air	***C10***	13.9	43.9	5.3
	40 mm	***C3***	12.1	84.0	9.0
	40 mm	***C4***	11.9	85.0	9.0

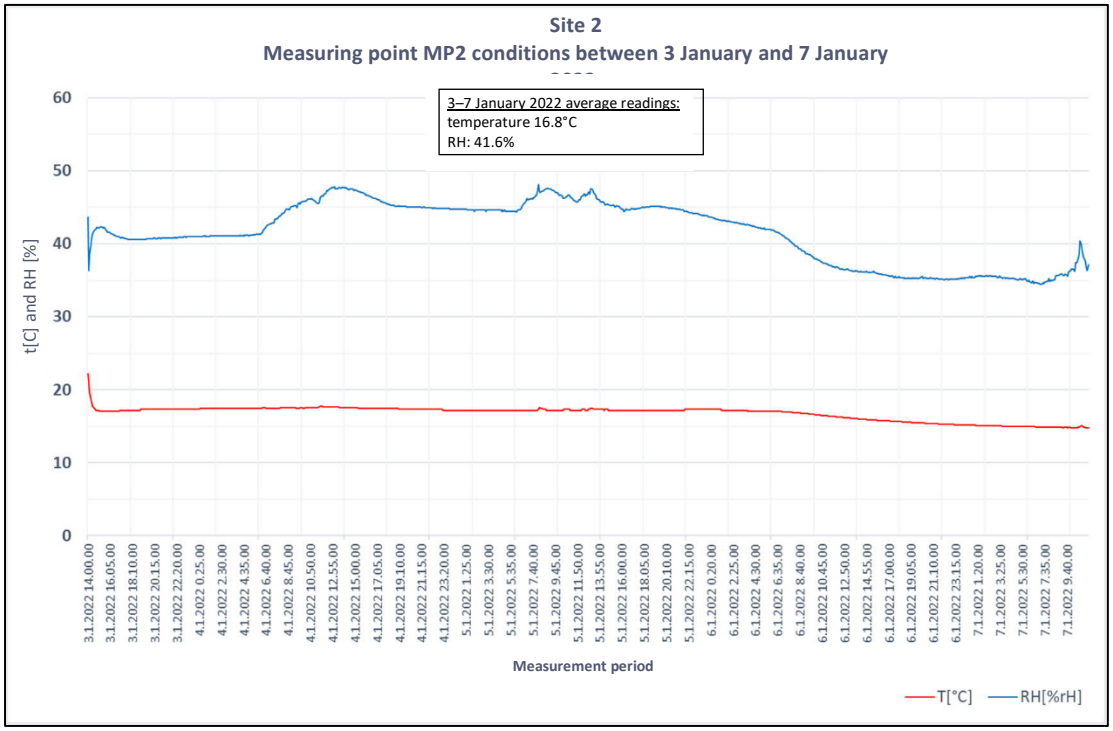


Table 5. *Site 1, humidity measurement results and temperatures of measuring points MP1 and MP2 of the eGate system between 26 October 2021 and 7 January 2022.*

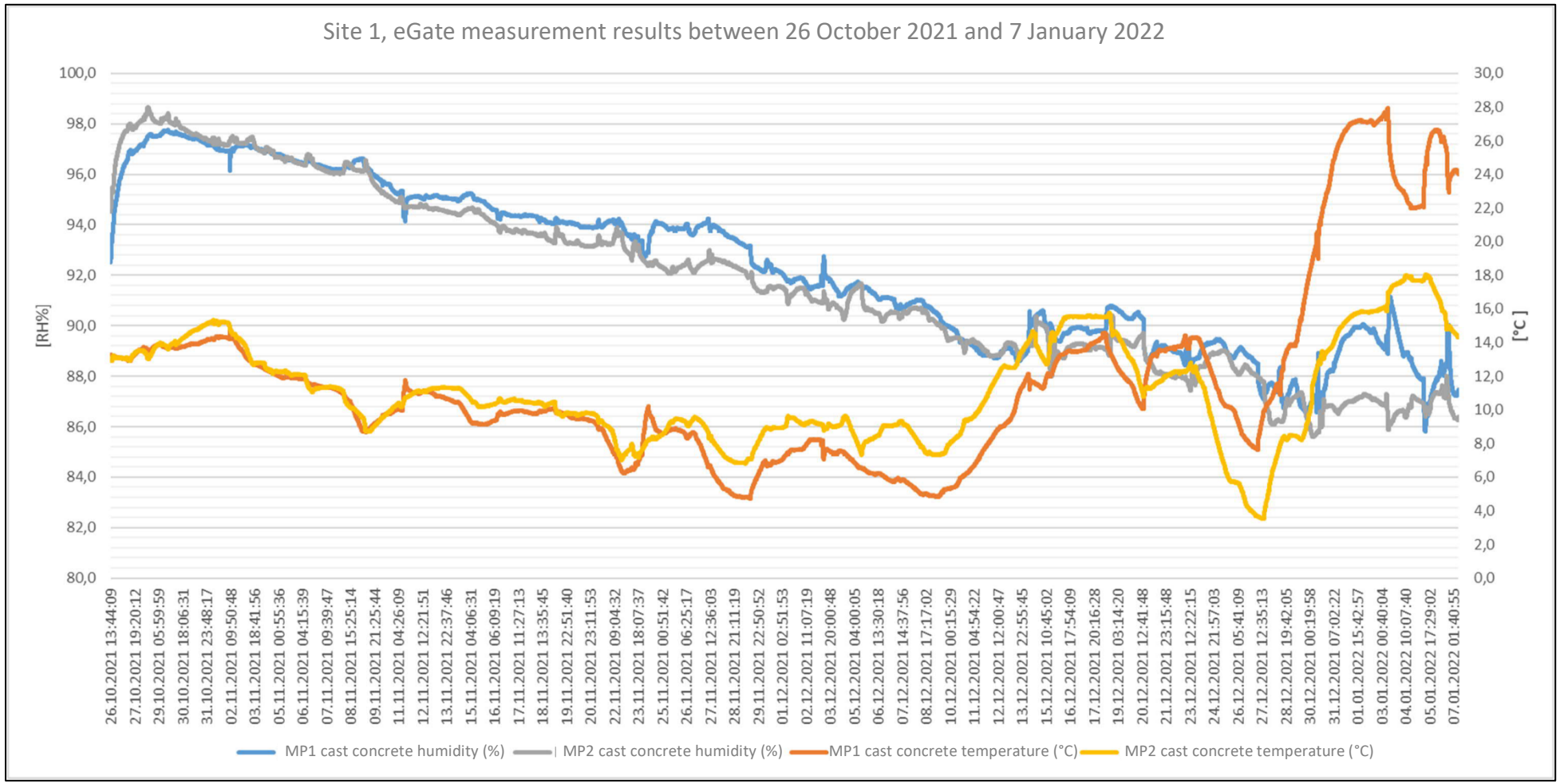
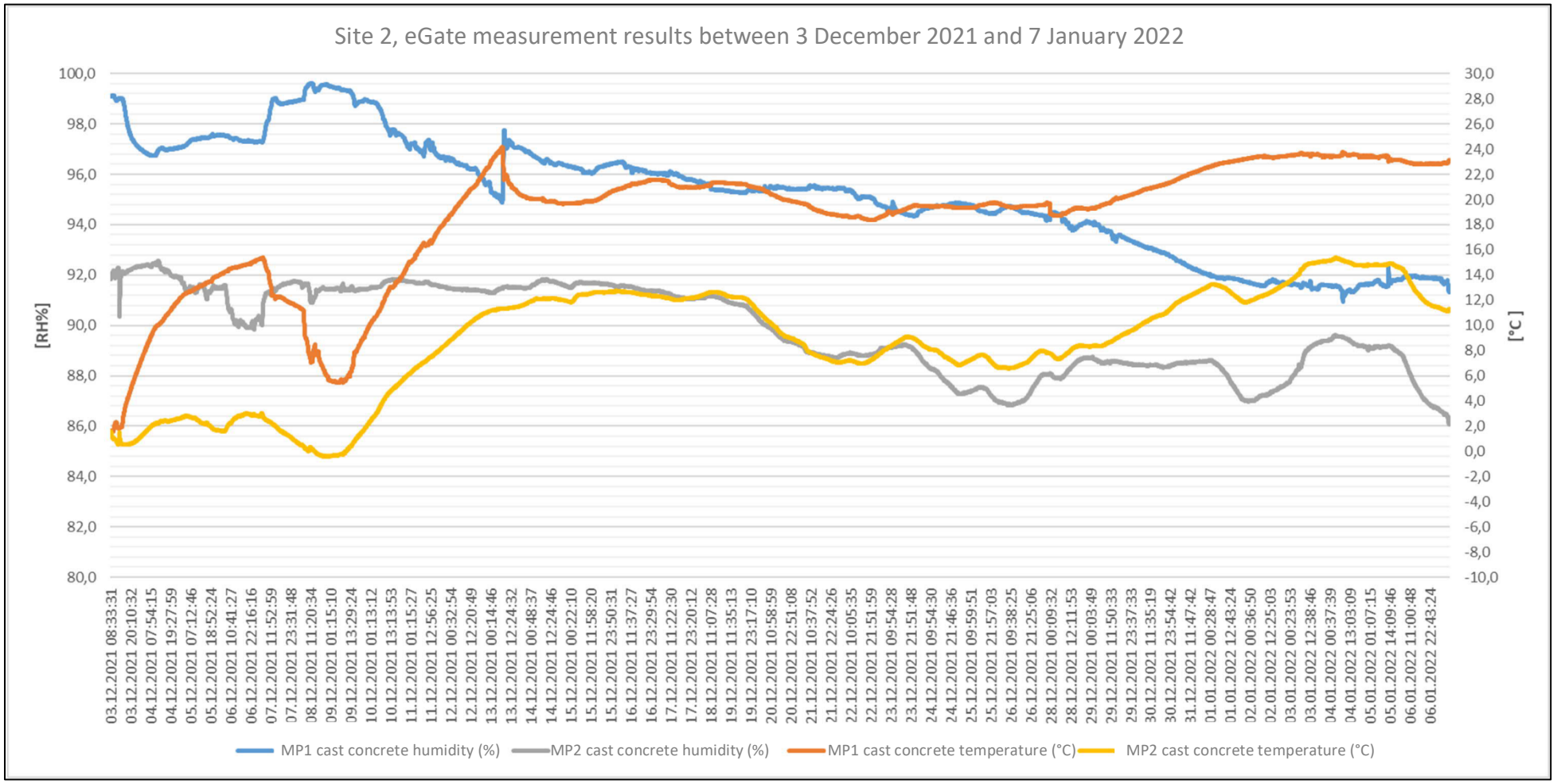


Table 5. *Site 2, humidity measurement results and temperatures of measuring points MP1 and MP2 of the eGate system between 3 December 2021 and 7 January 2022.*



4 Inspection of results and conclusions

Site 1

The reading given by the relative humidity and temperature measuring probe in the eGate system at measuring point MP1 on 7 January 2022 at 08:45 a.m. was 87.5 RH%. According to the measurements taken at the fresh borehole logging points (average of two parallel boreholes), the relative humidity of concrete was 89.9 RH% after 96 hours of stabilisation. The temperature was 24°C according to the eGate system and 24.2°C based on the borehole measurement.

The reading given by the relative humidity and temperature measuring probe in the eGate system at measuring point MP2 on 7 January 2022 at 08:38 a.m. was 86.3 RH%. According to the measurements taken at the fresh borehole logging points (average of two parallel boreholes), the relative humidity of concrete was 86.1 RH% after 96 hours of stabilisation. The temperature was 14.4°C according to the eGate system and 14.0°C based on the borehole measurement.

Site 2

The reading given by the relative humidity and temperature measuring probe in the eGate system at measuring point MP1 on 7 January 2022 at 12:20 p.m. was 91.7 RH%. According to the measurements taken at the fresh borehole logging points (average of two parallel boreholes), the relative humidity of concrete was 92.5 RH% after 96 hours of stabilisation. The temperature was 22.9°C according to the eGate system and 23.1°C based on the borehole measurement.

The reading given by the relative humidity and temperature measuring probe in the eGate system at measuring point MP2 on 7 January 2022 at 12:30 p.m. was 86.5 RH%. According to the measurements taken at the fresh borehole logging points (average of two parallel boreholes), the relative humidity of concrete was 84.5 RH% after 96 hours of stabilisation. The temperature was 11.3°C according to the eGate system and 12.0°C based on the borehole measurement.

Based on the studies conducted and the reference measurements taken, the measurement results of the sensors in the eGate system were very close to the results obtained from the fresh borehole logging points at both sites and both measuring points. In the reference measurement, the class of total uncertainty of measurement of the fresh borehole logging points has been estimated to be ±2 RH% for measuring points 1 and ±3 RH% for measuring points 2.

The measurement results of the eGate system were within -2.4…+2.0 RH% units compared to the results obtained through borehole logging: - 2.4 … +0.8 RH% for measuring points 1 and +0.2 …+2.0 RH% for measuring points 2. Thus, nearly all the measurement results given by the eGate system were within the tolerance of the estimated uncertainty classes of ±2 and ±3 RH%

Espoo, 14 February 2022
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