Measurement of Road Climatological Variables

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INTRODUCTION

Road climatology is a field within applied climatology where knowledge regarding spatial and temporal variations of such parameters as air and road surface temperatures as well as humidity is of great importance. These variables controls the risk of local slipperiness to occur and it therefore important to be aware of how these parameters should be measured in order to give proper information to maintenance personal or others responsible for keeping roads safe. During the 1970´s the first road weather information systems where developed. These systems where design for measurement of such parameters that early warnings of road slipperiness could be given. To achieve this field stations where located near highways where the local conditions favours early development of road icing.

Today these kinds of systems are widely used around the world. However, a very important aspect regarding RWIS is – what is the quality of the data delivered by the field stations, how well are the road climate conditions covered by use of stations sited along the road and with sensors far from, in a micro climatological point of view, the active surface, i.e. the road surface. An ongoing research project sponsored by the Swedish National Road Administration, addresses questions like these. In the present paper an introduction is given to the methods used and some preliminary results.

BACKGROUND

At a test site outside Gothenburg, Sweden, measuring towers have been placed in a profile starting at the roadside and with increasing distance from the road. The towers are equipped with temperature sensors at different heights to be able to cover the variation caused by the ground among other things. In Figure 1 a temperature recording is shown for a clear night situation (29 of March), at 21:00 hours. The temperature curves represent the conditions above the road asphalt and a nearby grass covered area. The distance between the towers is approximately 6 meters. Close to the ground the temperature differs significantly between the two towers due to the influence from the ground.

Temperature is also recorded in a profile from the road surface and down in the roadbed. The temperature recording in Figure 1 shows that the temperature change near the ground is dramatic and that the temperature gradient in the roadbed also is large.

This example shows that it is very important to have knowledge about the micro climatological conditions at the RWIS-station and also that the exact location of the sensors are crucial. Previous studies by Chen et al (1999) and Karlsson (1999) show result in agreement with this conclusion.

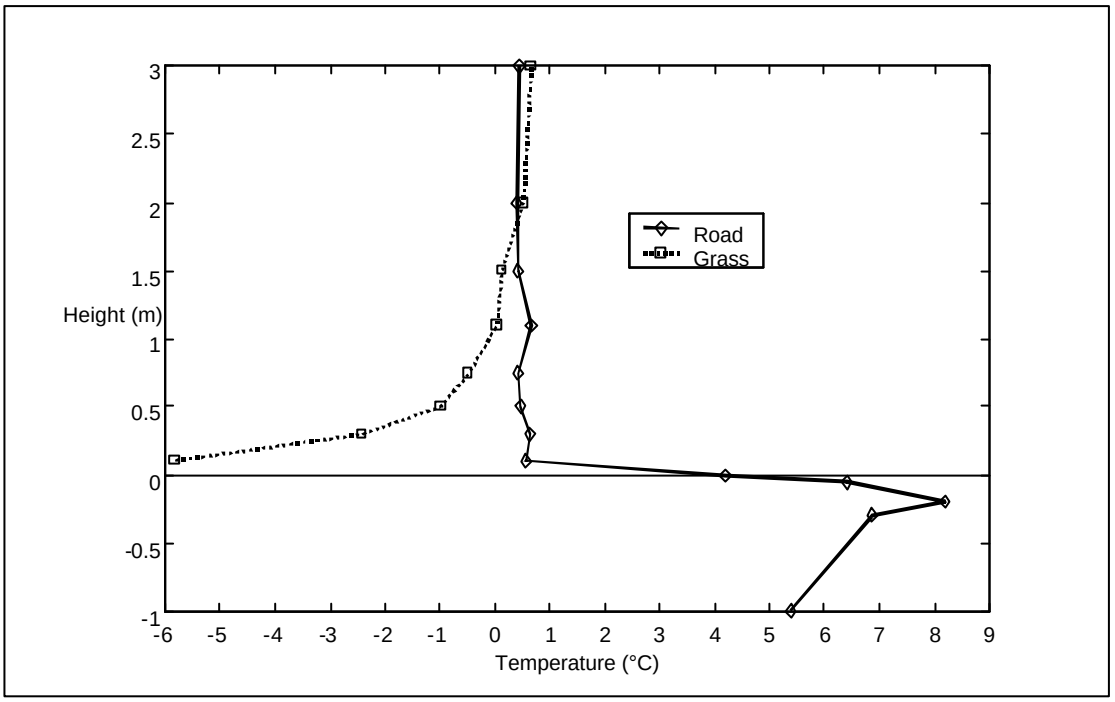

Figure 1. Temperature measurements over to different type of surfaces; a road surface and a grass surface

METHODS

In order to study the exact location of stations and sensors in the Swedish RWIS a test are very chosen. In the county of Halland, southern part of Sweden, 11 RWIS-stations very examined in closed details regarding theses factors.

In Figure 2 the parameters that where measured is shown. *A* – is the distance between the tower and the road; *H1* – is the height of the sensor relative the ground and *H2* is the height relative the road surface; *Y* is the distance from the roadside to the road surface temperature sensor. Each surface sensor was also studied carefully in relation to such parameters, as colour of coating is relation to the asphalt and distance between the sensor and the surface.

Detailed surface temperature measurement was also conducted by use of IR-thermometer (Raynger MX4). This type of sensor is very accurate for surface temperature measurements and has a very fast response time (275 mS). The sensor has a spectral response in the 8 to 14 ?m wave band.

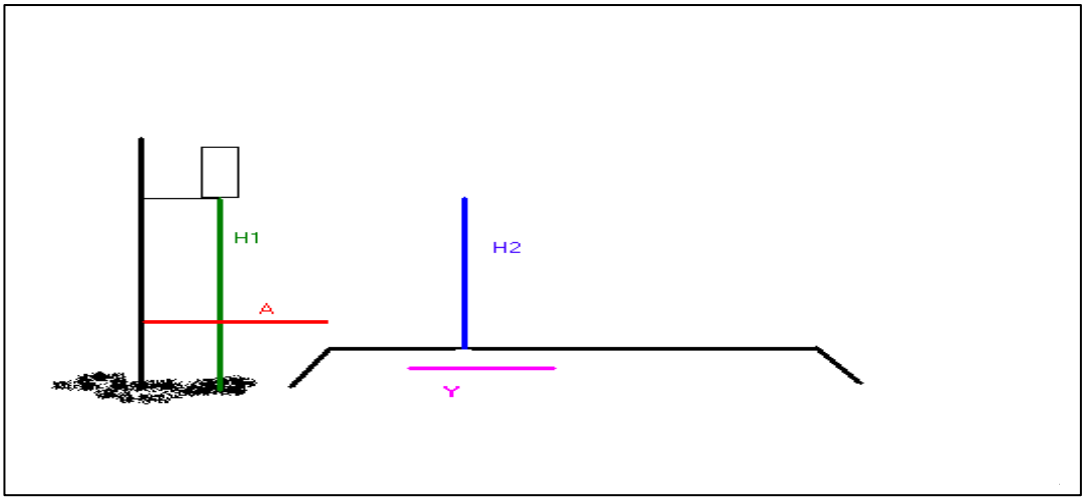

Figure 2. Measured parameters at the field stations.

RESULTS

Location of field station

The result from the measurement of the exact position of the sensors at the field stations is shown in Table1. The result indicate that the stations differs significantly in relation to height and horizontal distance from the roadside.

Table 1. Position of the RWIS-station in relation to the road. Notation is shown in Figure 2.

RWIS-id	*Type of area*	*A (m)*	*H1 (m)*	*H2 (m)*	*Y (m)*
1306	Open, bridge	2,5	3	2,2	2,7
1307	Open	2,3	2,4	1,9	2,2
1308	Forest	3	2	2,45	2,0
1311	Forest	2,6	2,8	2,05	2,5
1314	Open	2,15	2,5	2,25	2,55
1315	Forest	3,2	2,45	2,7	2,3
1316	Open	4,1	3,25	2,05	2,35
1317	Forest, dense	3,35	2,5	2,5	4,45
1330	Open	4	3	1,7	2,1
1332	Open	2,2	2,6	2,2	2,55
1333	Open, bridge	0,6	2,5	2,5	2,4

The distance from the roadside differs between 0,6 to 4,1 meter. This will result in that the influence from the type of ground will vary a great deal. At the distance of 4 meter the temperature will not be influenced by the road conditions at all, and at levels close to the ground the temperatures will during some weather occasions differs very much compared to the conditions above the road.

The height from the ground or road surface towards the sensor also differs among the studied stations. However, at these stations this will only have a minor influence on the temperature measurement. The temperature profiles presented in Fig1 shows that the influence from the ground diminishes with increasing height and at 2 meters level the temperature are the same.

Surface sensors

In the study detailed observation was undertaken regarding the location of the surface temperature sensor. In Table 2 this is shown by the fact if the sensor is visible or not. Among the 11 stations studied 6 of them had a visible sensor. The sensors also differ in respect of coating, especially the colour of the coating. The coating is added to protect the sensor. However, it is very important that the coating material do not differs significantly from the asphalt layer close to the sensor. Both colour and texture are factors that can influence the thermal reaction. In Table 2 the colour of each coating is listed and it is clear that it varies a lot between the studied stations.

Table 2. Description of the surface temperature sensors studied.

RWIS-id	*Coating*	*Visible sensor*
1306	Light brown	No
1307	Black	Yes
1308	Black	Yes
1311	Black	No
1314	Light green	Yes
1315	Black	No
1316	Light green	Yes
1317	Black	No
1330	Light brown	Yes
1332	Light brown	Yes
1333	Light brown	No

Road surface temperature measurements

In order to study if the surface temperature sensor give accurate information about the real surface temperature control measurements using an IR-thermometer was used. IR-measurements were carried out during both clear days and nights. Together with the

measurements manual checking of the surface sensor also was conducted. The result from this study are summarised below:

1) The surface temperature is mostly lower that the value given by the sensor.
2) The largest difference in temperature between the sensor and the surface was found during clear days and among sensors covered by black coating.
3) Surface temperature sensors covered by grey coating showed the smallest variation in temperature between sensor and asphalt.
4) Large temperature difference between sensor and asphalt surface was most commonly found during situation with a change in temperature.

The result from the detailed control measurements shows very clearly that the exact positioning of the surface temperature sensor is crucial. If the sensor is placed to deep in the roadbed the temperature response is affected, resulting in a slower response to temperature changes. This will also result in a large temperature difference between the surface and the temperature recorded by the sensor, especially during clear day situation with intense heating of the surface or during clear night with intense cooling of the surface.

Conclusions

In order to perform temperature measurements of high quality it is essential to have good control over factors that influence the measurements. Location of field stations and sensors are example of such factors that will influence the accuracy and how well the performed measurements can give valuable information to maintenance personal.

In this project 11 stations were studied in relation to the above-mentioned factors. The results show that the stations differs a great deal both in respect of location of the station in relation to the road surface and the location of the stations. Especially regarding the road surface temperature sensor is important to have proper knowledge about the depth and coating. Control measurements with use of IR-technique showed that large temperature differences can occur between sensor and surface.

References

Chen, D., Gustavsson, T. & Bogren, J. 1999: The applicability of similarity theory to a road surface. *Meteorol. Appl.* **6**: 81-88.

Karlsson, M. 1999: Local and micro climatological studies with emphasis on temperature variations and road slipperiness. *Thesis A42 Earth Sciences Centre, Göteborg University, Sweden.*