DEVELOPMENT OF THE ROAD SURFACE OBSERVATION SYSTEM

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1. Summary

The present road management system categorically requires a road surface observation system to monitor the latest road surface conditions, but in the winter time, it often becomes difficult to keep trucking the latest road surface conditions because of the degraded measuring accuracy due to bad weather such as blizzard, or because of inability of measuring the snow melting chemicals being spread over. It is a crucial issue to develop a system which can overcome all the shortcomings.

The road surface observation system which is going to be introduced this time is a system that can resolve the problems with new ideas.In the year 2001 in Japan, the field test was conducted on actual roads, which proved that the system was worthwhile for actual applications.We are presently planning to develop "the freeze prediction algorithm" for the system, with which the safe operation of the ITS will be greatly enhanced in the near future.

2. Introduction

The newly developed road surface observation system consists of road surface sensors that are buried in the road (buried sensors) and laser type road sensors(laser sensors). Each sensor detects the dry, wet, frozen or snow covered condition of the road, based on the different operating and detecting principles, and delivers wide spread and visual information for monitoring the road surface conditions.

This paper describes the development and effect of road surface observation system, based on the field tests conducted on the actual roads in Japan.

3. The features of the road surface observation system

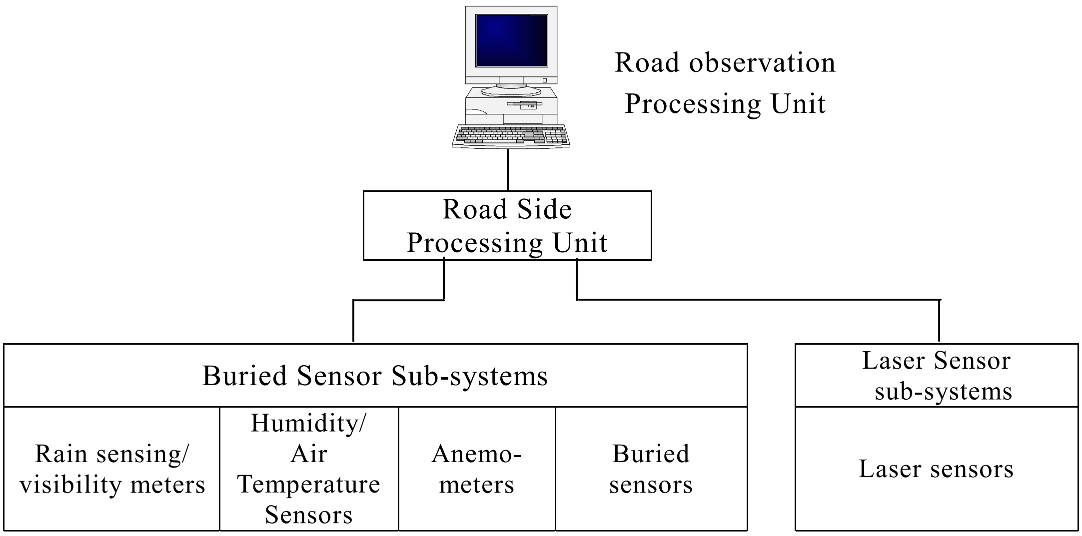


Fig.1 Schematic of the road surface observation system

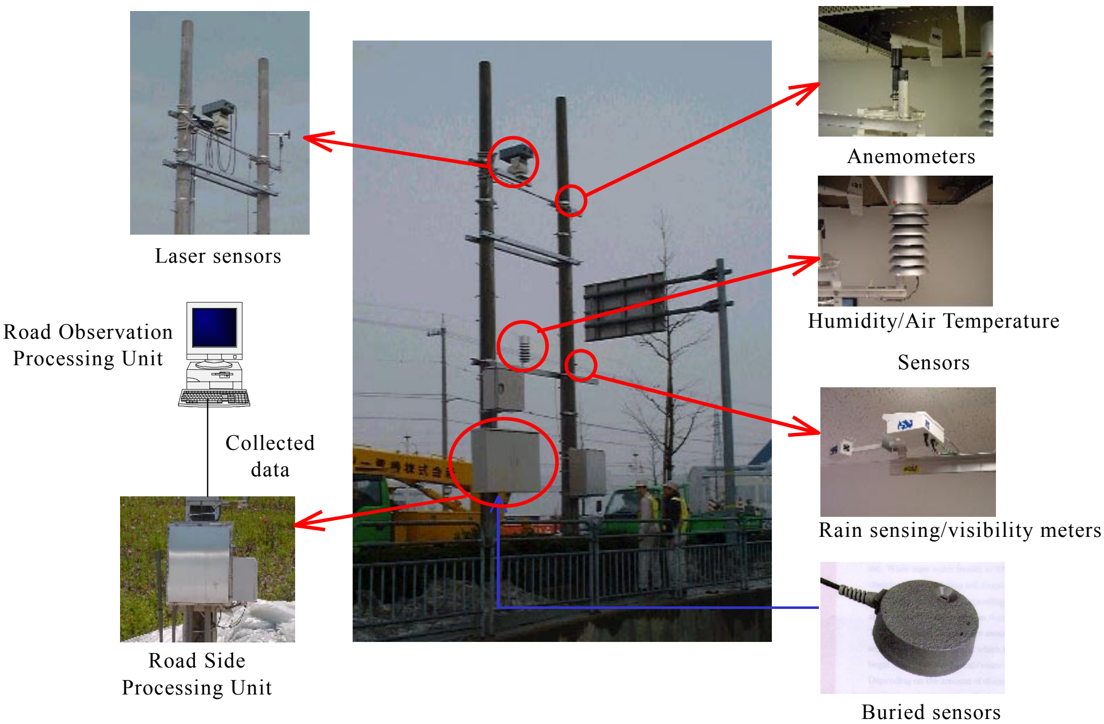


Fig.2 Photographs of the road surface observation system

3.1 Buried Sensor Sub-system

The Buried Sensor Sub-system comprises a variety of sensors as shown in Table.1 and 2 to measure the road and weather conditions and makes a judgment on the condition of the road based on the collected data.

Table 1 Measurement of the sensor sub-system

Sensors	Measurement of	Measuring ranges
Buried sensor	Road surface temperature	-30～+50℃
	Amount of water (depth)	0.3～12.7mm
	Amount of ice	0～100%
	Salt content	0～26% (Saturated consistency)
Anemometer (incl. wind direction)	Wind speed	0～44m/s
	Wind direction	0～360°
Rain sensing/ visibility meter	Weather	Judgment of rain or snow
	The strength of rain or snow	High, Medium, Low
	Visibility	0～1.8km
Humidity/Air Temperature Sensors	Temperature	-35～+70℃
	Humidity	0～100%

The road surface observation system can make the judgment of the road surface condition in seven classifications, which are larger than the conventional classification.

Table 2 The judgment classification of the road surface conditions

Dry	Damp	Wet	Snow/Ice Watch	Snow/Ice Warn	Frost	Chemical Wet

3.2 Laser sensor sub-system

The laser sensor sub-system detects snow or ice on the road by scanning laser beam on the road and analyzing the reflected signal thereby. The detected snow or ice on the road is displayed as an image as shown in Fig. 3. Visual cameras are also installed to obtain information about the detecting timing and the traffic conditions of the road.

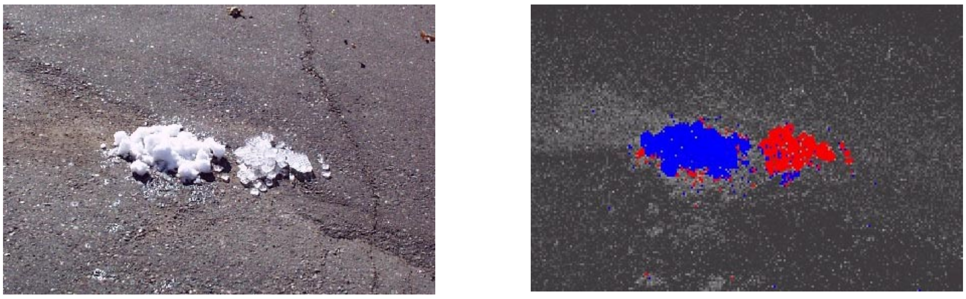


Fig. 3 The actual screen image (left) and the processed image (right)
(Ice: Red Snow: Blue Other than ice/snow: Gray)

Table 3 Specifications for the laser sensor

Laser wavelength	850nm
Laser power	0.99W
Laser class	Class 1 (IEC Standard) Not harmful even the beam comes into a naked eye.
Detecting area	About 20 m × 7 m (from 7 m high position) The minimum measuring area: 50 × 40 mm
Number of pixel	200 × 300 pixel
Snow depth	By the increment of 1 cm (to be developed in 2003)

4. Field tests on actual roads

The field tests were conducted to verify the function and performance of the system.

(1) Summary of the tests

- Location : Vicinity of Omachi intersection on Route 8, Fukui-shi. (Within the jurisdiction of Fukui Construction Work Office, Kinki Regional Development Bureau, the Ministry of Land,Infrastructure and Transport)
- Period : February - March, 2001
- Test Method : We defined that the visually witnessed road surface conditions were true conditions. And the detected road surface conditions by the system were compared with the true conditions.

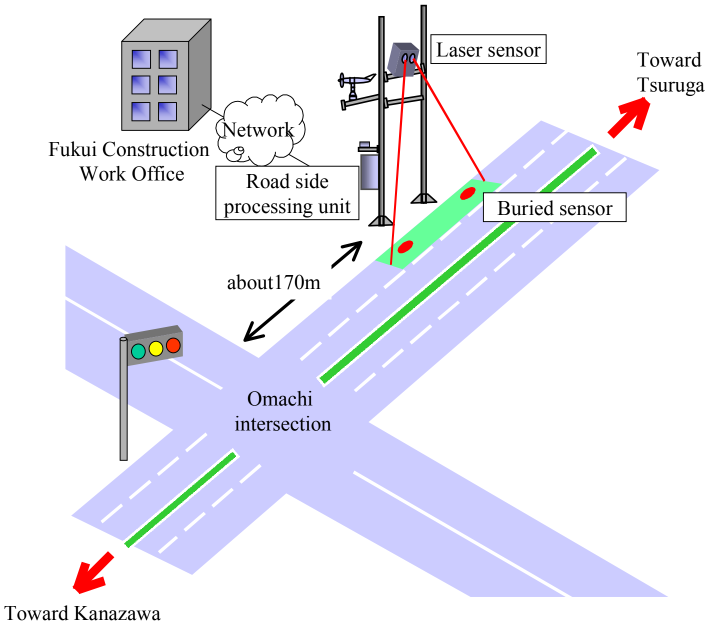


Fig. 4 The arrangement of sensors, etc. at the field test

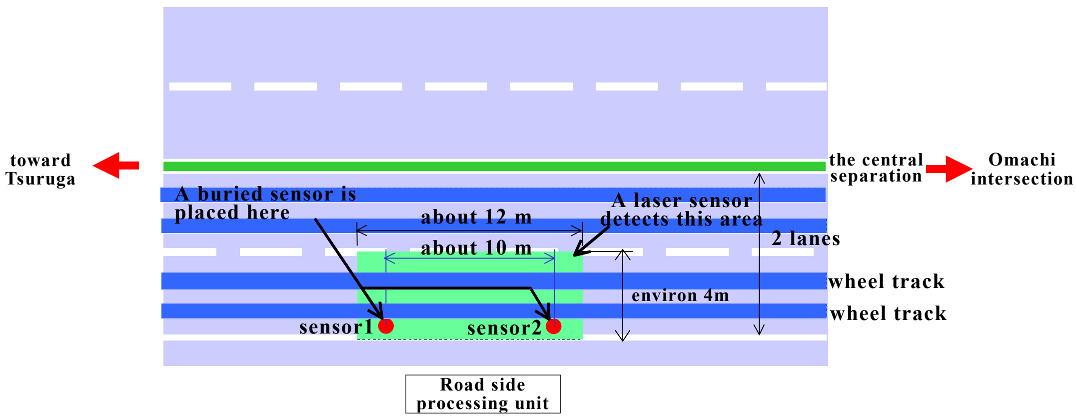


Fig. 5 The area on which data were collected

- Two pieces of buried sensors were installed about 10 meters apart from each other, and about 10 cm outside the outer wheel track on the traffic lane.
- A laser sensor covers the area of 12 m × 4 m on the traffic lane including the two buried sensors.

(2)The collected data

Part of the data collected during the field tests is shown below.

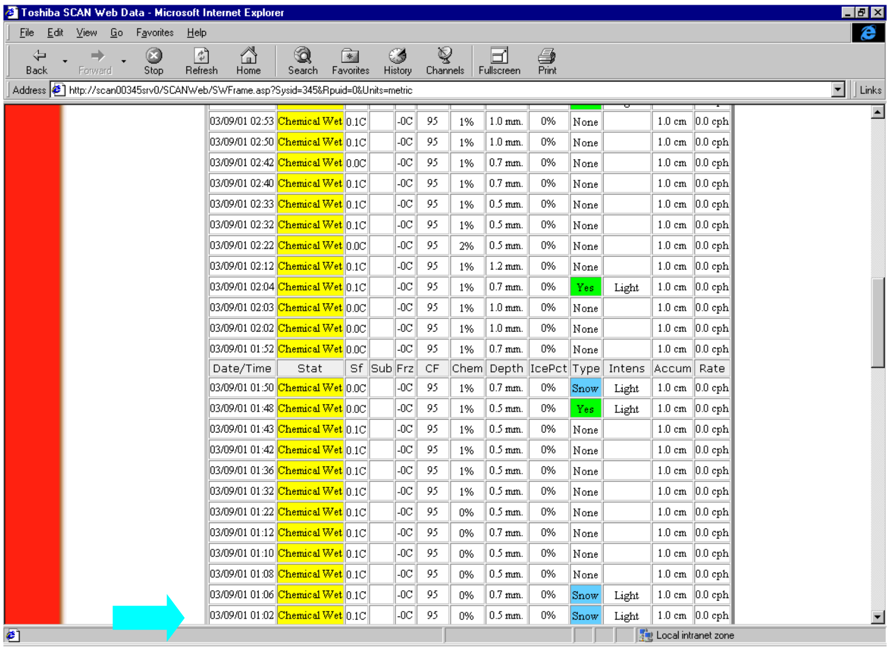
The data indicate the road surface condition that was sherbet-like (chemical wet)(1:00, March 9, 2001).

As shown in Fig. 6, the road surface condition was chemical wet on the area other than the wheel track and wet on the wheel track. Weather was light snowing.

Fig. 7 shows that buried sensor sub-system detected the road surface condition as chemical wet.

In Fig. 8, the laser sensor sub-system detected the ice part contained in the chemical wet in the area other than the wheel track.

Fig. 6 Photographs of the road surface condition



03/09/01 02:53	Chemical Wet	0.1C		-0C	95	1%	1.0 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:50	Chemical Wet	0.1C		-0C	95	1%	1.0 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:42	Chemical Wet	0.0C		-0C	95	1%	0.7 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:40	Chemical Wet	0.1C		-0C	95	1%	0.7 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:33	Chemical Wet	0.1C		-0C	95	1%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:32	Chemical Wet	0.1C		-0C	95	1%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:22	Chemical Wet	0.0C		-0C	95	2%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:12	Chemical Wet	0.1C		-0C	95	1%	1.2 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:04	Chemical Wet	0.1C		-0C	95	1%	0.7 mm.	0%	Yes	Light	1.0 cm	0.0 cph
03/09/01 02:03	Chemical Wet	0.0C		-0C	95	1%	1.0 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 02:02	Chemical Wet	0.0C		-0C	95	1%	1.0 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:52	Chemical Wet	0.0C		-0C	95	1%	0.7 mm.	0%	None		1.0 cm	0.0 cph
Date/Time	Stat	Sf	Sub	Frz	CF	Chem	Depth	IcePct	Type	Intens	Accum	Rate
03/09/01 01:50	Chemical Wet	0.0C		-0C	95	1%	0.7 mm.	0%	Snow	Light	1.0 cm	0.0 cph
03/09/01 01:48	Chemical Wet	0.0C		-0C	95	1%	0.5 mm.	0%	Yes	Light	1.0 cm	0.0 cph
03/09/01 01:43	Chemical Wet	0.1C		-0C	95	1%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:42	Chemical Wet	0.1C		-0C	95	1%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:36	Chemical Wet	0.1C		-0C	95	1%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:32	Chemical Wet	0.1C		-0C	95	1%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:22	Chemical Wet	0.1C		-0C	95	0%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:12	Chemical Wet	0.1C		-0C	95	0%	0.7 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:10	Chemical Wet	0.1C		-0C	95	0%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:08	Chemical Wet	0.1C		-0C	95	0%	0.5 mm.	0%	None		1.0 cm	0.0 cph
03/09/01 01:06	Chemical Wet	0.1C		-0C	95	0%	0.7 mm.	0%	Snow	Light	1.0 cm	0.0 cph
03/09/01 01:02	Chemical Wet	0.1C		-0C	95	0%	0.5 mm.	0%	Snow	Light	1.0 cm	0.0 cph

Fig. 7 The screen display of the buried sensor sub-system

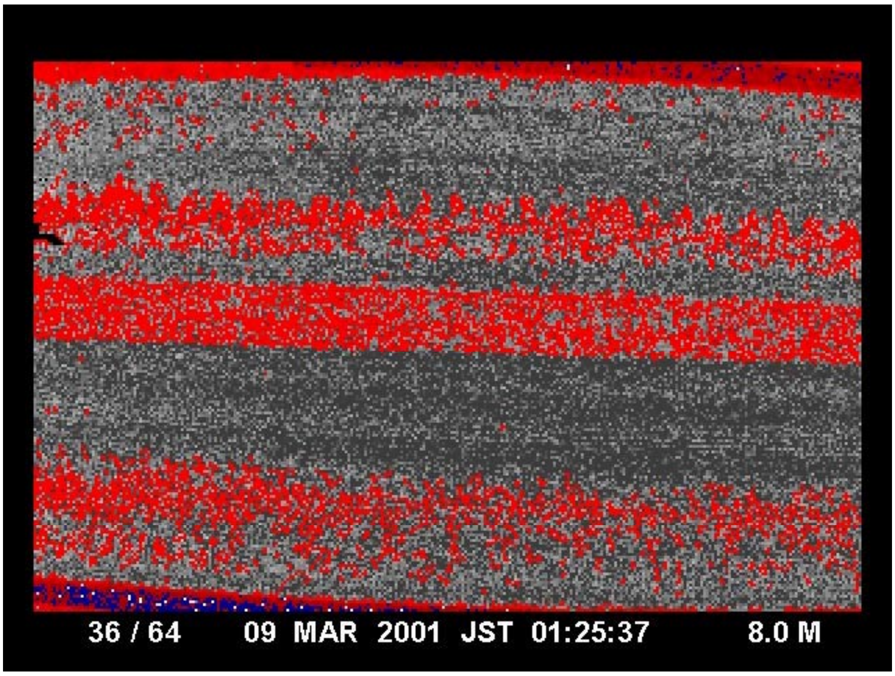


Fig.8 The screen display of the laser sensor sub-system
(Ice: Red Snow: Blue Other than ice/snow: Gray)

(3)Evaluation

- The rate of coincidence to the road surface condition was more than 90%. In the cases of incorrectness, they were still within the tolerance. The coincident rate (judgment on the road condition) was quite high.
- Detection of snow/ice on the road was also as high as more than 90%. Detection errors were mainly caused by the water content on the road.
  Detection of the water content was not considered in the last test, but the function of detecting the water content is planned to be added to the next test, that is hoped to be resulted in higher measuring accuracy.
- By adding the function of detecting the salt consistency, it was possible to measure the amount of snow melting chemical splayed and the most effective timing of the splay.
- By collecting real time information about the road surface conditions, it was possible to recognize the details of the changes and history of the road surface conditions.
- Fogs did not appear during the test and thus it was not possible to confirm the influence of the fogs. But the measurement was least affected by the weather condition such as snowing.
- Detection of both snow and ice was made on area and visually to have a better understanding about the road surface condition.

5. The future development plans

- We develop the freeze prediction algorithm, based on the data acquired during the field tests last year.
- We add the water detecting function to the laser sensor sub-system which exhibited great accuracy on detecting snow/ice in the field tests.

6. Conclusion

Through the field tests on the actual roads, the road monitoring and surveillance function was confirmed to be made in seven classifications and on area and visually, thereby the application to the actual scene is greatly expected. With system in use, the road management and maintenance organizations will be able to provide detailed and real time information about the roads to the users of the roads. The measurement of salt consistency may reduce the splay of surplus chemicals, which will result in reducing the maintenance cost as well as preserving the environment. This is regarded as one of the systems that can highly contribute to the local society.

The road surface observation system that was developed this time, after improving the various problems that were inherent in the conventional system, is a system which is expected to be highly effective in the ITS. The freeze prediction algorithm and the snow depth measuring function of the increment of 1 cm are the most advance area to be developed and implemented.