Practical Application of a Road Pavement Condition Assessment System to the Mine Road Network in Yamaguchi

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1. Introduction

This paper describes a result of practical application of a road pavement condition assessment system to the Mine-city road network in Yamaguchi. For the road pavement, "Maintenance Control Index(MCI)" which is an index for road pavement damage is widely applied for its condition assessment by using a special designated car in Japan[1)]. MCI can be used to assess the road surface condition by quantitatively based on the level of crack rate(%), maximum rut depth(mm) and standard deviation of smoothness(mm). As an another index, "International Roughness Index(IRI)" also attracted attention in Japan[1),2)]. However, initial cost and operating costs for both methods mentioned above are relatively high, and the frequency of the use of inspection car tends to be low. The aim of this paper is to make practical application a newly developed road pavement condition assessment system, called "Ippo-Campo"[1)-3)] to the Mine-city road network in Yamaguchi Prefecture for confirming the effectiveness of the system.

2. Outline of Proposed System (Ippo-Campo)

Fig. 1 shows the configuration of a road pavement condition system(Ippo-Campo) with the video data, sound data, subtitle data, sensor data and GPS data. In the system, at first, it needs to arrange the measuring equipment in a car as shown in Fig. 2, then the car was running at the speed of 50~60 km/h for evaluating the target road route. In the running car, data acquisition from the high-vision video, motion sensor and running wheel sound were done into a PC.

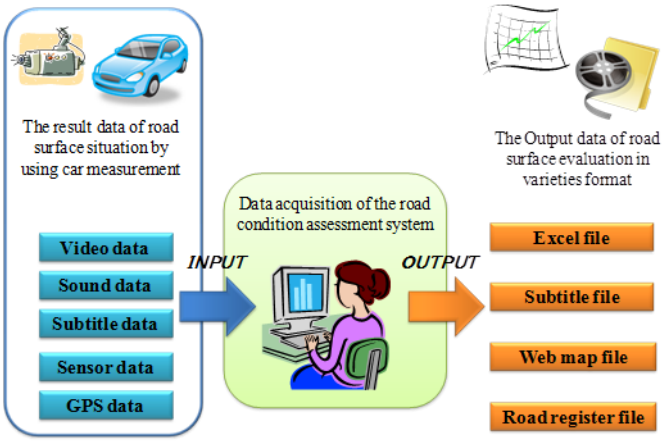

Fig. 1. Configuration of a proposed system

Fig. 2. Arrangement of measuring equipment in a car

It takes about 20 minutes to arranging the measurement equipment in a car, and it is possible for just a person to as the driver and also the operator to check the status of the installed equipment while it is recording Z-axis accelerations data and video movie. As shown in Fig. 2, the arrangement of measuring equipment in a car, including motion sensor, GPS antenna, high vision camera-microphone and suction cup camera mount connect to a PC by using proper cables and ready for the measurement.

The measurement provides a good correlation with the road surface and at the same time, the standard deviation of running wheel sound and Z-axis acceleration by using terminated evaluation signal of running wheel sound at 150~250Hz. Moreover, data of measurement will be analyze to get the output data in varies types, that is the excel file, video and subtitle file, web map file, and road register file. The output file of evaluate data shows the specific condition of the road pavement in three differences color and sign, which are green color(good) with the symbol of ○, yellow color(moderate) with the symbol of △ and red color(bad) with the symbol of ×. Table 1 shows an example of the out data from an excel file. It can be seen from Table 1, × symbol which means the bad road condition are more dominant in it. Fig. 3 shows an example of video and subtitle file. It illustrates the situation of road by showing the sub title data through the movie file. Furthermore, Fig. 4 summarizes an example of output data which is shows the condition of the road trough web map data. It illustrates in 3 highlighted colors, red as a bad condition, yellow as moderate and green represented the good condition.

3. Practical Application to the Mine Road Network

3.1 Target road route

The assessment of the road pavement condition was conducted in the Mine-city(Yamaguchi prefecture) jurisdiction road network, belonging in the "Ube Civil Engineering Mine branch office". As shown in Fig. 5, the target roads are also located in the Mine-city and the total distance of the measured road is 8,050m. Table 2 listed the detail of line name, type of road and the distance of each target road route. The reason to conduct the field test in the Mine-city is that of the Yamaguchi prefecture was doing repairing works of the road pavement in this location. The measurement was doing in two ways, at first the "Ube Civil Engineering Mine branch office" conducted a road evaluation by using a patrol car. The objective is to collect the information of

Table 1. Example of output data from an excel file

JST	Latitude	Longitude	Map	Point distance	No.of satellites	Judgment
2012/2/16 16:08:20	34.1784	132.0643	Map	14.0722	7	○
2012/2/16 16:08:21	34.1784	132.0642	Map	12.6593	7	△
2012/2/16 16:08:22	34.1784	132.064	Map	14.1230	7	△
2012/2/16 16:08:23	34.1784	132.0639	Map	14.1230	7	△
2012/2/16 16:08:24	34.1784	132.0637	Map	14.2241	7	×
2012/2/16 16:08:25	34.1785	132.0635	Map	15.6163	7	×
2012/2/16 16:08:26	34.1785	132.0634	Map	14.2241	7	×
2012/2/16 16:08:27	34.1785	132.0635	Map	12.9113	7	×
2012/2/16 16:08:28	34.1785	132.06331	Map	14.2931	7	×

Fig.3. Example of movie file with subtitle

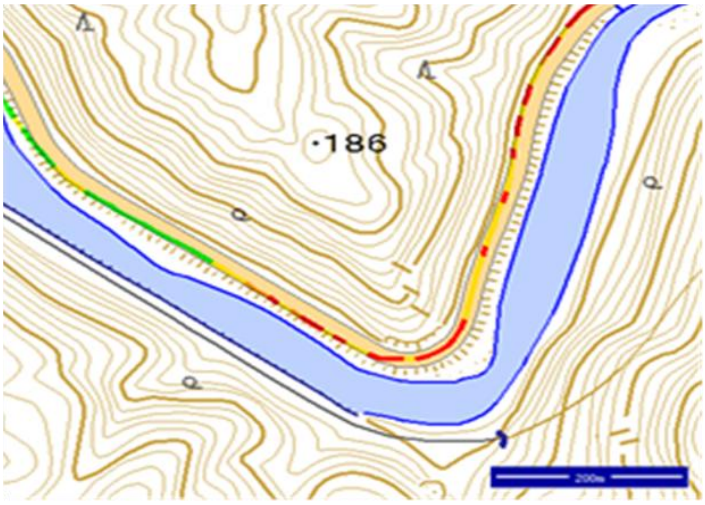

Fig.4. Example of web map file

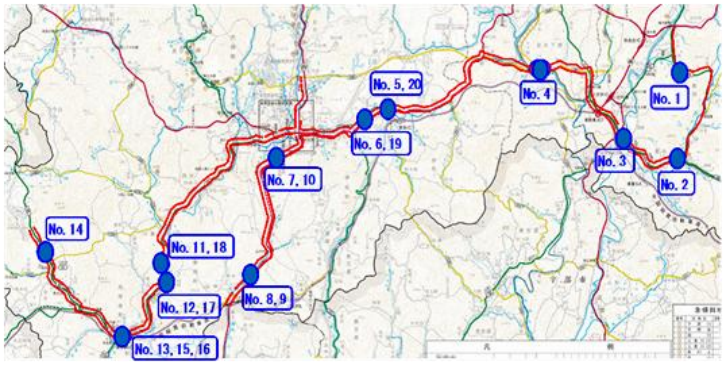

Fig.5. Map of target road route

Table.2 No. and name of target road route

No	Type of road	Line No.	Line name	Length (m)
1	Prefecture road	28	Ogouri misumi line	350
2	Prefecture road	31	Mito line	400
3	Prefecture road	31	Mito line	550
4	Prefecture road	240	Yunoguchi Mine line	700
5	National road	435	435 line	600
6	National road	435	435 line	200
7	National road	316	316 line	650
8	National road	316	317 line	350
9	National road	316	318 line	350
10	National road	316	319 line	650
11	Prefecture road	33	Shimonoseki Mine line	300
12	Prefecture road	33	Shimonoseki Mine line	350
13	Prefecture road	33	Shimonoseki Mine line	400
14	Prefecture road	65	Sanyou Toyota line	200
15	Prefecture road	33	Shimonoseki Mine line	400
16	Prefecture road	33	Shimonoseki Mine line	150
17	Prefecture road	33	Shimonoseki Mine line	350
18	Prefecture road	33	Shimonoseki Mine line	300
19	National road	435	435 line	200
20	National road	435	435 line	600

Table 3. Verification results of pavement condition before and after repair

JST	Cumulative distance	Repair interval	Z-axis acc.	Velocity of the car	Judgement using Z-axis acc.	Judgement using Z-axis acc. and sound data
Before repair						
2013/2/23 9.26.03					×	×
2013/2/23 9.26.04					×	×
2013/2/23 9.26.05	0.0		0.343	52.8	×	×
2013/2/23 9.26.06	14.7		1.222	52.8	×	×
2013/2/23 9.26.07	29.3		0.203	52.8	×	×
2013/2/23 9.26.08	43.8		0.362	52.8	×	×
2013/2/23 9.26.09	58.4		0.972	52.8	×	×
2013/2/23 9.26.10	73.1		0.347	52.8	○	×
2013/2/23 9.26.11	87.8		0.376	52.0	○	○
2013/2/23 9.26.12	102.2		0.266	51.8	○	○
2013/2/23 9.26.13	116.6	1	0.243	51.8	○	○
2013/2/23 9.26.14	131.0		0.306	54.3	○	○
2013/2/23 9.26.15	146.6		0.246	52.0	○	○
2013/2/23 9.26.16	160.5		0.223	53.6	○	○
2013/2/23 9.26.17	175.4		0.239	52.8	○	○
2013/2/23 9.26.18	190.0		0.285	53.6	○	○
2013/2/23 9.26.19	204.9		0.247	52.0	○	×
2013/2/23 9.26.20	219.4		0.204	53.3	○	☆
2013/2/23 9.26.21	234.2		0.202	53.6	○	☆
2013/2/23 9.26.22					△	△
2013/2/23 9.26.23					○	○
After repair						
2013/11/16 10.20.23					○	○
2013/11/16 10.20.24					○	○
2013/11/16 10.20.25	0.0		0.267	32.1	○	○
2013/11/16 10.20.26	8.9		0.267	32.1	○	○
2013/11/16 10.20.27	17.8		0.250	32.4	○	○
2013/11/16 10.20.28	26.8		0.324	37.9	○	○
2013/11/16 10.20.29	37.4		0.210	36.9	○	○
2013/11/16 10.20.30	47.6		0.308	40.9	○	○
2013/11/16 10.20.31	59.0		0.231	39.9	○	○
2013/11/16 10.20.32	70.1		0.243	43	○	○
2013/11/16 10.20.33	82.0	1	0.224	41.4	○	○
2013/11/16 10.20.34	93.5		0.208	43	○	○
2013/11/16 10.20.35	105.4		0.224	44.5	○	○
2013/11/16 10.20.36	117.8		0.283	44.5	○	○
2013/11/16 10.20.37	130.1		0.215	46	○	○
2013/11/16 10.20.38	142.9		0.200	46	○	○
2013/11/16 10.20.39	155.7		0.207	48.3	○	○
2013/11/16 10.20.40	169.1		0.206	46	○	○
2013/11/16 10.20.41	181.9		0.200	47.5	○	○
2013/11/16 10.20.42	195.1		0.193	48.7	○	○
2013/11/16 10.20.43	208.6		0.204	45.7	○	○
2013/11/16 10.20.44					△	△
2013/11/16 10.20.45					×	×

the rut depth with maximum volume more than 40 mm. As the second way, there was conducted a measurement by using Ippo-Campo.

3.2 Measurement details

In this study, the data was obtained on the road measurement using a sedan-type of car. The car was driven at the speed of 50 km/h~60km/h and the Mti-G configuration sampling rate is 100 Hz. The measurement was doing in two ways recording, from start point to the end point and overturn. This measurement was conducted in condition before and after repair of the road pavement. The objective of measurement is to compare with the results of both conditions and to confirm the efficiency of the system. The confirmation evaluation result of the output data is using GPS data, movie data and road register data. The interval time of measurement is recording the data on every second. As shows in Table 3, it records the condition of road at every second in Japan System Time (JST). In this practical application, there are principal notes that been excluded due to avoiding the efficiency of data measurement such as small sample number (less than 4 points), bridge interval, railways, tunnels and traffic jam.

3.3 Results and discussions

In Table 3, the data verification results show an example of the road repair point. The highlighted sign indicates the repair interval and the output result by using Ippo-Campo. It also illustrates the condition before and after repair. The uper site of table shows how bad of the road condition before repair which is dominant by × symbol. However, the bottom site of table is represented the road condition after repair, which is dominant by ○ symbol, signified that the road is in good condition. The total road pavement repair points are 57, excluded 23 points as the number of sample less than 4. It used two methods of data processing, standard deviation of Z-axis acceleration and the combination with sound data.

Table 4 shows the remaining sample that has more than 4 numbers of samples and the result of comparison road pavement condition before and after repair. The result illustrates percentage of comparison between the bad point and the number of

Table 4. Comparison data of before and after pavement repair work using Z-axis acceleration and running wheel sound data

No	Type of road	Line No.	Line name	Length	Before repair				After repair			Validity
					number of sample (S)	X ☆△ (B)	B/S (%)	B/S < 50%	number of sample (S)	X ☆△ (B)	B/S(%)	
1				200	17	9	53		19	0	0	
2	Prefecture	28	Ogouri misumi line	310	23	16	70		25	4	16	
3	Prefecture	31	Mito line	480	39	32	82		36	3	8	
4	Prefecture	31	Mito line	450	31	4	13	!	32	2	6	
5	National	435	435 line	270	21	16	76		20	0	0	
6	National	316	316 line	580	41	39	95		41	2	5	
7	National	316	316 line	420	27	23	85		28	4	14	
8				170	16	7	44	!	14	0	0	
9				80	7	2	29	!	6	1	17	
10	National	316	316 line	270	17	17	100		21	1	5	
11	National	316	316 line	600	37	37	100		31	2	6	
12	Prefecture	33	Shimonoseki Mine line	320	23	16	70		23	5	22	
13	Prefecture	33	Shimonoseki Mine line	200	14	14	100		12	3	25	
14				150	11	11	100		11	0	0	
15	Prefecture			150	10	6	60		11	2	18	
16		65	Sanyou Toyota line	440	30	19	63		26	4	15	
17				420	29	20	69		25	8	32	
18				140	11	9	82		9	1	11	
19				120	10	8	80		9	2	22	
20	Prefecture	33	Shimonoseki Mine line	100	7	7	100		8	1	13	
21	Prefecture	33	Shimonoseki Mine line	170	10	10	100		12	2	17	
22	Prefecture	33	Shimonoseki Mine line	180	13	7	54		12	5	42	
23	Prefecture	33	Shimonoseki Mine line	320	22	12	55		21	3	14	
24	Prefecture	33	Shimonoseki Mine line	80	9	4	44	!	5	1	20	
25				160	12	6	50		12	1	8	
26				150	10	10	100		11	3	27	
27				160	12	12	100		12	5	42	
28				230	15	11	73		15	6	40	
29	National	435	435 line	290	21	19	90		20	7	35	
30	National	435	435 line	520	38	38	100		45	18	40	
31				590	37	37	100		37	8	22	
32				250	17	5	29	!	16	3	19	
33				230	15	10	67		16	2	13	
34				250	15	9	60		61	6	10	

sample for before repair condition is higher than condition after repair.

It is also found that there are still 5 missings (sample No. 4, 8, 9, 24 and 32) that the percentage of the bad point are not change because the rut depth is bigger than wheel path.

4. Conclusions

The main conclusions obtained in this study can be summarized as follows:

1. An IT-based road condition assessment system(Ippo-Campo) has been developed based on digital movie, vehicle vibration and sound with GPS & low cost constraint.
2. The proposed system was applied to an actual road network in Mine-city area to evaluate its effectiveness. As the results, it will be able to make a rational maintenance strategy for repairing works.

References

1. Nakano, T. Yoshitake, T. Miyamoto, A. "Study of road condition assessment system, Using Digital Movie, Vehicle vibration and Sound, Yamaguchi University, 2012.
2. T. Yoshitake, K. Mizobe, N. Yasumura A. Miyamoto “Development of the road condition assessment system using digital movie, vehicle vibration and sound” JSCE F4, Vol. 69, No.1, pp 12-31, 2013.2.
3. Miyamoto, A. & Yoshitake, T. “Development of a Remote Condition Assessment System for Road Infrastructures ”International ECCE conference, EUROINFRA 2009, Current State and Challenges for Sustainable Development of Infrastructure, Symposium 1,Helsinki, Finland：pp. 21-22, (USB Memory：pp. 109-124)：October 2009.