SERVICEABILITY SURVEY OF INTERLOCKING BLOCK PAVEMENT USING AN AUTOMATIC SURFACE CHARACTERISTICS SURVEY VEHICLE

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ABSTRACT

Since surface characteristics of Interlocking Block (ILB) pavements, which have been increasingly applied to carriageways, are important information for their maintenance management, the use of an automatic surface characteristics survey vehicle (Survey Vehicle) seems to be suitable because of its quick data acquisition ability.
Surface characteristics survey of ILB pavements for 3 to 10 years in service was conducted using Survey Vehicle which is usually used for survey of asphalt pavement etc. and traditional manual methods to compare their test results, and the serviceabilities of these pavements were evaluated based on Maintenance Control Index (MCI) developed by the Ministry of Construction, Japan.
For ILB pavements, Survey Vehicle on which a multiple laser rangefinder system for rutting measurement and a 3 point laser rangefinder system for longitudinal roughness measurement are mounted is practically applicable, because the test results of these laser systems are almost equal to those of traditional methods.
Test sites of ILB pavements which were designed and constructed according to "Technical Guide for Design and Construction of Interlocking Block Pavement for Carriageway" is maintaining good serviceability with MCI value of more than 6.5 even after 6 years or more in service. And the test site after 3.5 years in service maintains MCI value as good as asphalt pavement on the site.
Test results using Dynamic Friction Tester on these test sites show good dynamic friction coefficients which are equal or higher than those on skid-resistant open-graded asphalt concrete, and skid resistance of ILB pavement for carriageway is sufficiently acceptable.

1. INTRODUCTION

Application of ILB pavement into cariageway has been increased year by year in Japan, because of its functional properties. Interlocking Block Pavement Engineering Association, Japan has published "Technical Guide for Design and Construction of Interlocking Block Pavement for Carriageway" (the Technical Guide-C) to respond the demands. On the other hand, only traditional manual methods using transverse profilometer and 3m (longitudinal) profilometer have been used to survey transverse and longitudinal roughness of ILB pavement.

With the increase of ILB pavement applied into carriageway, a large volume of surface characteristics data will be needed for their maintenance management in the future. Since the use of Survey Vehicle seems to be suitable for these data collection, the pavement surface characteristics survey and evaluation were conducted on ILB pavement for carriageway.

This paper states the results of applicability of Survey Vehicle to ILB pavement, the results of serviceability evaluation based on MCI, and, at the same time, the skid resistance test results on ILB pavement are reported.

2. OUTLINE OF SURVEY

The tests were conducted on ILB pavements which were designed and constructed according to the Technical Guide-C and have been in service for 3 to 10 years.

2.1 Outline of Survey Vehicle

The Survey Vehicle is capable to measure rutting, longitudinal roughness and cracks required for evaluation of MCI simultaneously or independently, and Table 1 shows its measuring abilities. Rutting is measured using a multiple laser rangefinder system as shown in Figure 1, and longitudinal roughness is measured using a 3 point laser rangefinder system as shown in Figure 2. Cracks are recorded on 8mm VTR through CCD camera.

These systems are mounted on a compact RV as shown in Photo 1 which enables us to measure not only arterial roads but narrow town and rural roads.

Data collected by Survey Vehicle are processed and output using office computer.

Table 1 Outline of Survey Vehicle

Measuring Item	Type of Measuring Equipment	Measuring Range	Measuring Interval	Measuring Speed	Recording Method	Measuring Accuracy
Rutting	Laser rangefinder with multi-point measuring capability	2.0~3.8m	20m MIN 0.5m	0~80 km/h	Magneto Optical Disc	*1 ±3mm or less
Longitudinal Roughness	Laser rangefinder with 3-point measuring capability	1 measuring line	1.5m MIN 0.5m	0~80 km/h	Magneto Optical Disc	*2 ±30% or less
Crack	Non interlace CCD camera	2.0~3.8m	Continuous	0~50 km/h	8mm Video Tape	MIN 1mm width

*1 : compared with Transverse Profilometer
*2 : compared with 3m Longitudinal Profilometer

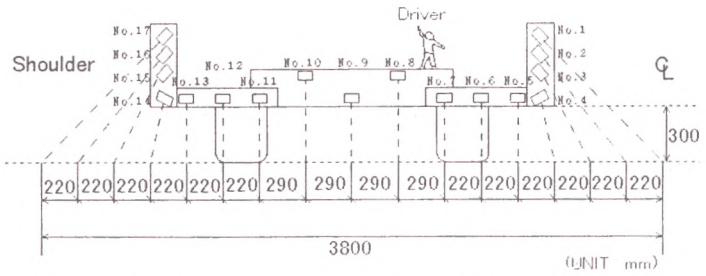


Figure 1 Layout of Laser Rangefinders for Rutting Measurement

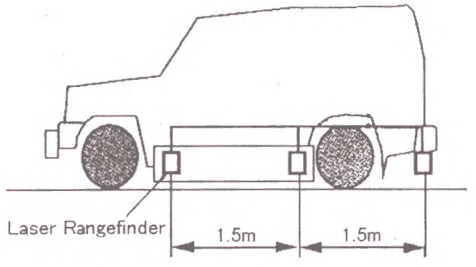


Figure 2 Layout of Laser Rangefinders for Longitudinal Roughness Measurement

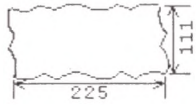
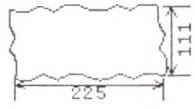
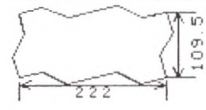



Photo 1 Exterior View of Survey Vehicle

2.2 Outline of ILB Survey Sites

The Technical Guide-C limits the application of ILB pavement up to Traffic Classification B (249-999 commercial vehicles/day/direction), and application examples only are introduced for Traffic Classification C (1000-2999 commercial vehicles/day/direction) or heavier. Therefore, one survey site each was selected for Traffic Classification A (100-299 commercial vehicles/day/direction), B and C, in which more ILB application is expected, among the sites where pavement structures and periods in service can be clearly confirmed. These selected survey sites are as shown in Table 2. Site B is a part of a bus terminal and Site C is a part of an airport terminal.

Table 2 Outline of Site Pavements

Survey Site	A	B	C
Years and Months in Service	10 and 2	6 and 2	3 and 6
Area (m^2)	3,800 (Sidewalk is included)	1,200	3,500
Traffic Classification	A Traffic	B Traffic	C Traffic
CBR (%)	—	3	4
Shape of IL Block			
Laying Pattern	Herringbone Bond	Herringbone Bond	Hrringbone Bond (45° Model)
Pavement Structure (mm)	IL Block 80 Bendding sand 30 Asphalt stabilization 200 Crushed stone for mechanical stabilization 150	IL Block 80 Bendding sand 20 Asphalt stabilization 150 Crushed stone for mechanical stabilization 150 Crusher-run 150	IL Block 80 Bendding sand 20 Asphalt stabilization 90 Crushed stone for mechanical stabilization 200 Crusher-run 400 Pit sand 750

2.3 Survey Items

(1) The selected survey sites were surveyed for rutting, longitudinal roughness and cracks using Survey Vehicle. Evaluation methods of these survey items and calculation method of MCI for serviceability evaluation are according to "Manual of Test Methods for Pavement"[1]. Rutting was evaluated using values measured at 20m interval, and longitudinal roughness was evaluated based on standard deviation of roughness obtained at 1.5m interval. Then MCI was evaluated for a full section at Site A and B, and for 100m section at Site C. For rutting, mean value for each section length used for MCI evaluation was used.

(2) For each survey site, traditional survey equipment were used for rutting and longitudinal roughness measurements. Rutting and longitudinal roughness were measured using a transverse profilometer as shown in Figure 3, and a 3m (longitudinal) profilometer as shown in Figure 4 respectively, and these results were read out from recorded papers.

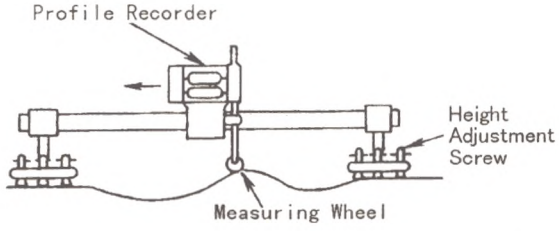


Figure 3 Transverse Profilometer

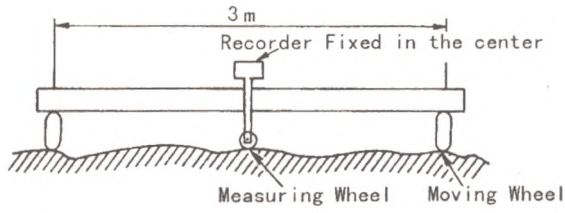


Figure 4 3m (Longitudinal) Profilometer

(3) Coefficient of dynamic friction at each site was measured using DF Tester as shown in Figure 5. Measured points were selected at inside and outside of wheel path. Coefficient of dynamic friction was read out from recorded papers at the disc rotation speed of 40, 60, and 80 km/h.

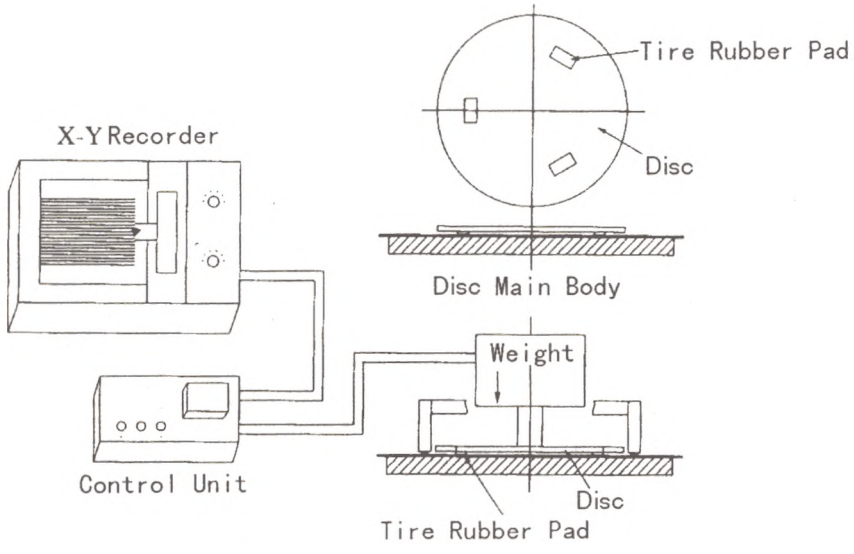


Figure 5 DF Tester

3. SURVEY RESULTS

3.1 Applicability of Survey Vehicle on ILB pavement

The applicability of Survey Vehicle was evaluated based on the conformity of test results by Survey Vehicle to those of traditional manual methods.

3.1.1 Rutting

The results obtained by Survey Vehicle and by a transverse profilometer at the same location are shown in Figure 6. The results show high correlation at both of the inside and outside of the left wheel path.
As can be seen, they have high correlation with almost same values. And the maximum deviation of rutting value is about 3 mm. This is almost equivalent to that of asphalt pavement.

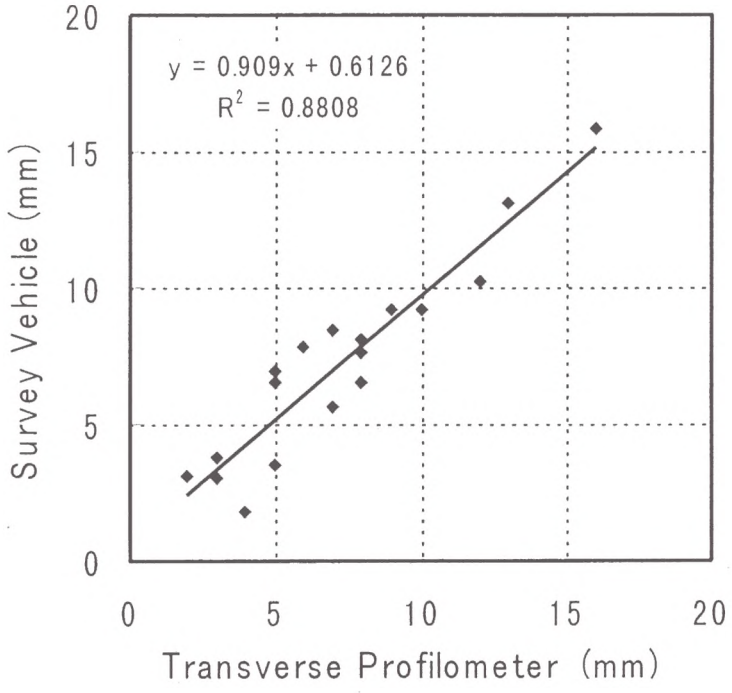


Figure 6 Relationship of Rutting Between Transverse Profilometer and Survey Vehicle

3.1.2 Longitudinal Roughness

The results of longitudinal roughness obtained by Survey Vehicle and a 3m (longitudinal) profilometer are as shown in Figure 7. The longitudinal roughness curves are almost the same. The calculated standard deviations which are the index of longitudinal roughness are 4.4mm by Survey Vehicle and 4.0mm by a 3m profilometer. This is also almost the same tendency to that of asphalt pavement.

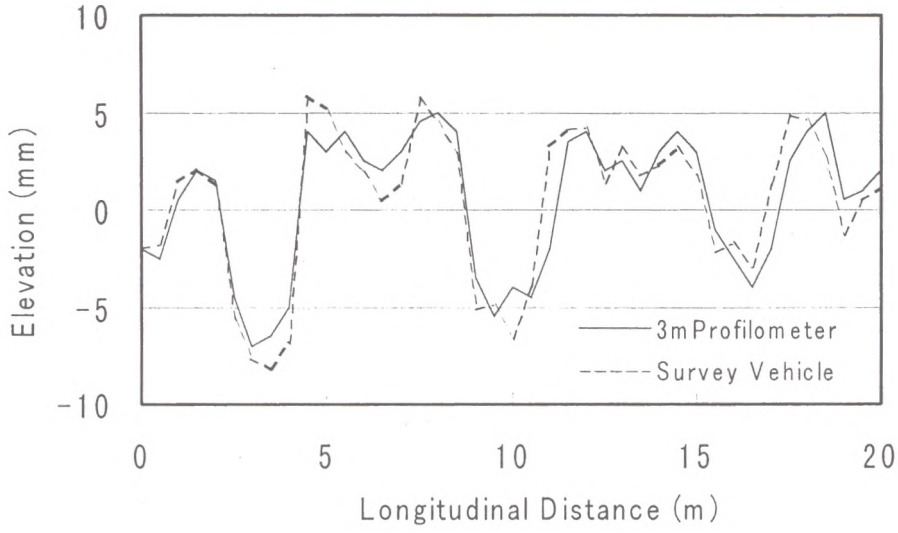


Figure 7 Measuring Results of Longitudinal Elevation using Survey Vehicle and 3m (Longitudinal) Profilometer

3.1.3 Cracks (Damages)

The self-detected results of image-processed tapes could not confirm cracks (damages) due to the effects of block joints. Image process recognizes joints as cracks because cracks are detected based on the mono-chrome tint during detection process. For the evaluation of cracks in ILB pavement through the lens, visual re-inspection of video-tape is required. Therefore, this method is not practically effective.

3.2 Serviceability Evaluation of ILB pavement

The survey results and data obtained by Survey Vehicle at each site and MCI values calculated based on them are as shown in Table 3. And based on the visual inspection of video-tapes and the sites, no cracks were found. Therefore, crack rate is 0% at all sites.

Table 3 Measuring Results of Surface Characteristics

Survey Site	Measurement Section Length (m)	Crack rate (%)	Rutting (mm)	Longitudinal Roughness σ (mm)	MCI Value
A	0-137	0	7.1	3.42	7.9
B	0-99	0	14.5	5.31	6.5
C	0-100	0	5.9	3.67	8.1
	100-120.5	0	7.8	2.57	7.7
	120.5-139 (Asphalt pavement)	0	8.0	4.52	7.7
	139-239	0	11.3	3.96	7.1
	239-339	0	7.5	3.06	7.8
	339-414.5	0	5.3	2.79	8.3

(1) In spite of a long period in service (for more than 10 years), Site A shows good surface characteristics with high MCI. It may be due to the relatively thick asphalt stabilized base with relatively low heavy vehicle traffic.
(2) Since Site B is located in a bus terminal, rutting depth is 14.5mm, longitudinal roughness is 5.31mm and MCI is 6.5, and these values show a little bit lower serviceability than other sites. It might be caused by local defects of joint openings and faults due to the twisting forces of steered wheels. However, since this site is opened to traffic for more than 6 years, the thermal characteristics of ILB is likely to contribute effectively to reduce deformation of pavement structure during high temperature in summer time.
(3) In spite of relatively shorter period in service (3.5 years), some sections of Site C show MCI as low as other older sections. Heavy bus traffic and the deformation of bedding sand might cause these low values. However, MCI values are almost the same to those of asphalt pavement section in the site, and it seems that there are no significant differences between ILB and asphalt pavements.
(4) MCI values obtained in this survey can be ranked as "preferable control level" according to MCI maintenance standards [2] developed by the Ministry of Construction, Japan, and it can be said that a good serviceability is maintained. Also, when referred to the evaluation ranks [3] which were used during formulating process of MCI formulas, these results can meet the rank of "good with little defects". These results, though the number of tests is too small, support the conformity of the current Technical Guide-C based on "Manual for Asphalt Pavement".

3.3 Skid Resistance of ILB pavement

The test results of coefficient of dynamic friction using DF Tester at each test site are shown in Table 4. In the table, 1 shows the values out of wheel path, and 2 shows values inside wheel path.

Table 4 Measuring Results of Coefficient of Dynamic Friction

Measuring Point No. / Speed km/h / Survey Site	1			2		
	40	60	80	40	60	80
A	0.63	0.58	0.50	0.59	0.58	0.53
B	0.71	0.70	0.62	0.77	0.74	0.69
C	0.61	0.56	0.52	0.56	0.53	0.51

At each test site, coefficient of dynamic friction is more than 0.5 at the speed of 60 km/h, and this is equivalent or more than that of open-graded asphalt pavement [4] which is used as skid-resistant pavement. Also, as coefficient of dynamic friction increases when the speed is lowered, this tendency is the same to that of asphalt pavement. Therefore, it can be said that there are no problems on friction of ILB pavement for carriageway.

As we can see little differences in values between 1 and 2, it seems that there is little skid resistance reduction due to vehicle wheels passing on ILB pavement.

4. CONCLUSION

(1) Rutting and longitudinal roughness of ILB pavement can be evaluated using Survey Vehicle on which laser rangefinder systems are mounted. However, it is difficult to evaluate cracks (damages) or joint openings using automatic analysis results of recorded tapes.
(2) All test sites of ILB pavements are evaluated to be maintained in good conditions, consequently, "Technical Guide for Design and Construction of Interlocking Block Pavement for Carriageway" is confirmed to be appropriate.
(3) ILB pavements are maintaining good skid resistance equivalent to or higher than asphalt pavement, therefore, there is no problems on skid resistance of ILB carriageway pavement.
(4) ILB pavements are sufficiently applicable to the places such as bus terminal where plastic flow resistance is highly required, and to the places where high skid resistance is required.

REFERENCES

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4. Kobayashi, T. (1997) Application Example of Porous Asphalt as Low Noise Pavement, Proceedings for Specified Subjects, the 22nd Japan Road Conference, pp.35-36.