The Credibility of Visual Survey Result against Pavement Performance Analysis

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ABSTRACT: In order to maintain the pavement in good condition in its service periods, periodical diagnosis, proper treatment and repair based on the diagnosis, and appropriate follow-up shall be important. The evaluation by visual survey by a pavement engineer and a longitudinal profile and rut survey vehicle will be two universal methods for the diagnosis.
The visual condition survey can be applied various types of road surface easily. However, it is common the accuracy and the variation of visual survey shall be evaluated closely before its practical use of the result. An inertial surface profiler and FWD are useful tools for verifying the visual survey result in order to ensure the credibility.
The study shows that the functional pavement condition can be predicted only by visual survey result at some level. In order to get reliable prediction of the future pavement condition, some of specific criteria for diagnosis are essential. Determination of traffic volume for evaluating road shall be one of the major factors to predict the structural damage of pavement.

KEY WORDS: visual survey, profiler, IRI, FWD.

1 INTRODUCTION

In order to maintain the pavement in good condition in its service periods, periodical diagnosis, proper treatment and repair based on the diagnosis shall be important. It is necessary to put the surface characteristic information in a database and to perform follow-up, such as progress observation, for appropriate control of maintenance.

We have two methods for diagnosis, one is longitudinal profile and rut survey vehicle which have measuring device, and another is the visual survey by pavement engineer. The vehicle is useful in survey of the road where lane width is constant in the fixed section like a national highway or ordinary road. On the other hand, visual survey method is suitable for investigation of the road surface which has various types like the yard road in a factory.

We shall first state the example of the evaluation method of surface characteristics in Japan. Then, how to estimate the damage of pavement by the visual survey which we proposed is shown. Furthermore, in the case study which conducted visual surveys, we evaluate the availability of this method based on the results of an investigation simultaneously measured using some equipments.

2 EVALUATION METHODS OF SURFACE CHARACTERISTICS

2.1 Maintenance Control Index (MCI)

MCI is an index which evaluates the performance of a road surface from a viewpoint of repair necessity. It was developed in Japan in early the 1980s.We often use vehicle which have measuring device for the purpose of measuring crack ratio, rut depth and smoothness. Laser sensors mounted the vehicle are used to measure rut depth and smoothness. Video camera mounted at the top of vehicle can provide us visual condition, and useful to assess the crack ratio. Recently, the system which detects a crack automatically using the picture captured by high definition camera is developed. MCI can be calculated easily using the formula (1). Generally, MCI is calculated for 20-100m of every road distance.

$$
\begin{aligned}
MCI_1 &= 10 - 1.48C^{0.3} - 0.29D^{0.7} - 0.47\sigma^{0.2} \\
MCI_2 &= 10 - 1.51C^{0.3} - 0.3D^{0.7} \\
MCI_3 &= 10 - 2.23C^{0.3} \\
MCI_4 &= 10 - 0.54D^{0.7} \\
MCI &= min(MCI_1, MCI_2, MCI_3, MCI_4)
\end{aligned}
\tag{1}
$$

Where:

C - Cracking ratio [%]
D - Rut depth [mm]
σ - Smoothness [mm]

When the value of MCI is four or less, it is estimated that a certain repair is required for the road surface. In a certain municipal corporation, the value of MCI is used for the aim of the rehabilitation design. In this study, since the visual evaluation of a road surface is a subject, calculation of MCI is not performed. The calculation method of MCI is introduced for reference.

2.1 Visual Inspection Score (VIS)

Although these vehicles can measure the surface characteristics accurately, the research cost is usually expensive. As a result, the rate of the research cost occupied to repair expense becomes high. Moreover, in the yard road where lane width is flexible and work yard of pavement, the measurement itself becomes complicated.

Then, we referred to MCI and devised the original visual inspection index. The item used for visual inspection selected the following four pavement condition carefully in order to carry out decision of survey and a rehabilitation design quickly at low cost. The relation of a pavement failure relevant to an item is shown in Table 1.

Table 1: Visual inspection items and failure

Item		Type of Failure
Cracks	x_1	Structural Failure
Roughness	x_2	Functional and Structural Failure
Potholes	x_3	Functional Failure
Aging	x_4	Another Failure

These four items are estimated by a pavement engineer who observes the pavement condition. The relation between an inspection score and a pavement condition is shown in a table 2.

Table 2: Inspection score and pavement condition

Score	Pavement Condition
0	Good
1	Fair
2	Poor

We defined the Visual Inspection Score (VIS) using the marking result of each item. The formula (2) shows the calculation method of VIS. The $f\,(x_i)$ of a formula means function of each item of Table 1. When there is no problem in all the items, VIS is marked with 10 points like MCI.

$$VIS = 10 - \{ af(x_1) + bf(x_2) + cf(x_3) + df(x_4) \} \tag{2}$$

The coefficient (*a, b, c, d*) was determined on the basis of the survey data of the municipal road in Saitama city. VIS enables us to estimate the risk of functional failure and structural failure of pavement.

3 THE CASE STUDY FOR EVALUATION OF VALIDITY

3.1 Visual condition survey

We investigated in order to verify the validity of visual evaluation on the yard road of a certain factory. According to the priority of pavement, the yard road was classified into three zones, an outside road (A), a workspace (B), and a parking lot (C). Work space (B) is a zone where the priority of repair is the highest. Furthermore, we separated each area into the block per one rehabilitation unit. Figure 1 shows the part of them. The number of blocks of zones and the average area of a block are shown in Table 3.

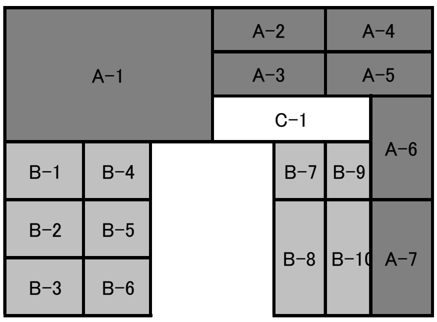

Figure 1: Block layout of zone

Table 3: The number of blocks of zones and the average area of a block

zone	block total	area[m^2]
A	51	235
B	98	330
C	10	880

3.2 Survey with equipment

While visual investigation is very easy, it cannot illustrate the credibility of an evaluation value. In order to clarify credibility of a visual evaluation value, comparison with the result measured by measuring device is indispensable. This section illustrates the equipment and examination contents which were used in order to verify the validity of a visual evaluation value.

(1) Multi-Road Profiler (MRP)

MRP is one of inertial profiler. We use MRP to measure longitudinal profile, micro-texture and rut depth. IRI is computed according to the quarter-car model using the profile data of MRP. The appearance of MRP is shown in Figure 2.

Figure 2: Multi-Road Profiler

(2)Falling weight deflectometer (FWD)

In order to comprehend the degree of the structural damage of pavement, we measured the deflection using FWD. It was measured in the arbitrary positions of the block where an obstacle does not exist. Moreover, because the structure of pavement is unknown, thickness of the pavement was estimated using electromagnetic waves.

Thus, the temperature-correction value of the deflection was calculated by the air temperature, surface temperature, mean temperature of pavement and pavement thickness.

Figure 3: Falling weight deflectometer and electromagnetic waves

3.3 Survey result

(1)VIS

Figure 4 shows distribution of VIS obtained by visual survey. The number beside VIS expresses the year which investigated. As may be seen from Figure 4, In “B” zone, there are many blocks of the class in which the VIS is higher than “A” zone.

Moreover, the dispersion of the score in “C” zone is small. Since heavy vehicles run frequently in “B” Zone, rehabilitation is periodically carried out so that the pavement can maintain a desirable state.

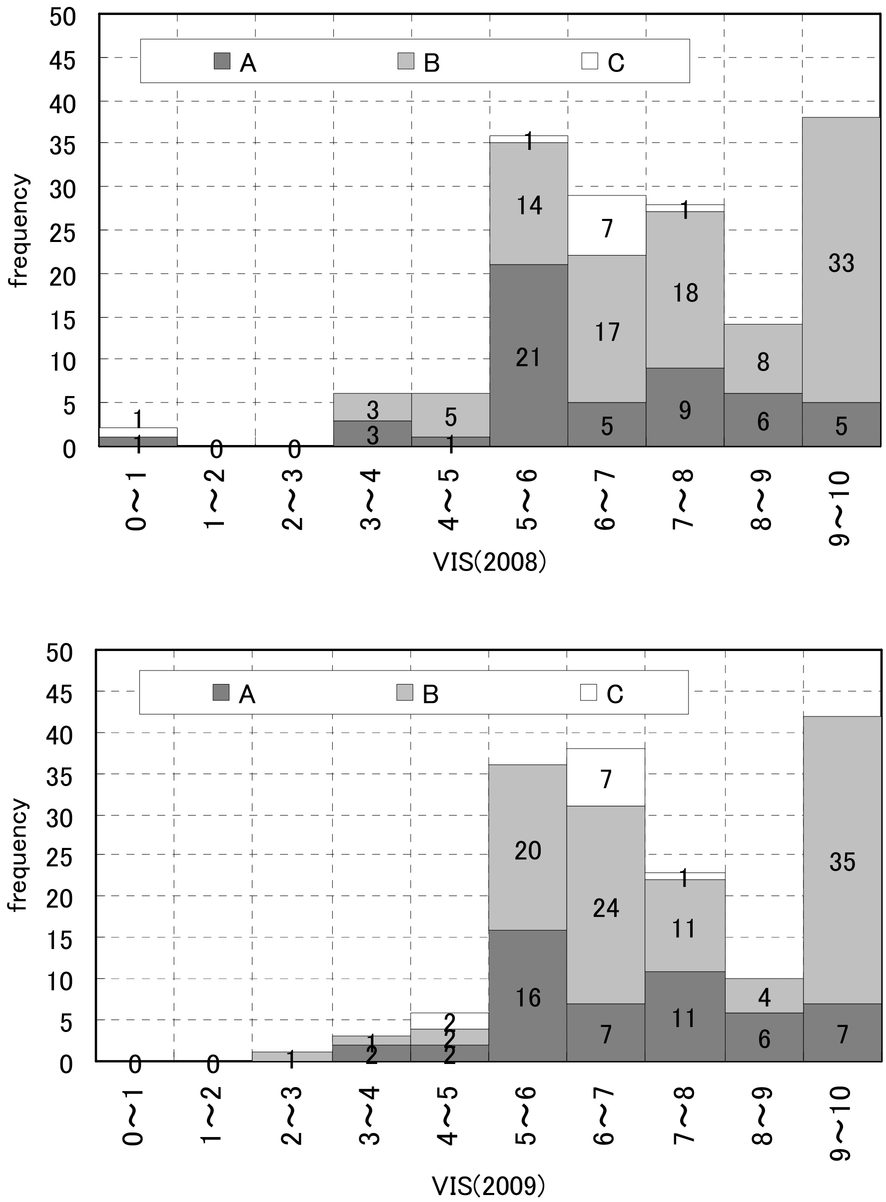

Figure 4: The distributions of VIS

We hope it is possible to estimate the rate of deterioration from two graphs. We did not find remarkable difference between them in “A”, “C” zone. However, in “B” zone, we can find differs clearly. These graphs show that the pavement deterioration rate in “B” zone is higher than other zones. A few damaged blocks are repaired in every year, and any blocks which were evaluated low does not exist in the next year.

(2)IRI

The distribution of IRI obtained from the longitudinal profile measurement data by MRP is shown in Fig. 5. Because the surface profile is measured in a part of “A” zone, the number of IRI data is different from VIS’s data.

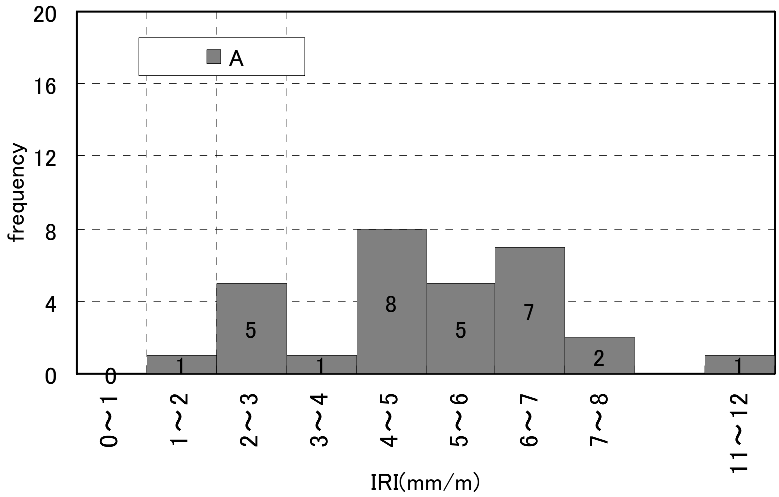

Figure 5: The distributions of IRI which measured by MRP

The management criteria of surface performance of the factory are not shown. From search result, it seems that the pavement will be repaired if IRI exceeds eight.

(3)Pavement deflection

The pavement deflection was measured where the obstacle to measurement does not exist in blocks. Therefore, the number of deflection data differs from VIS's data.

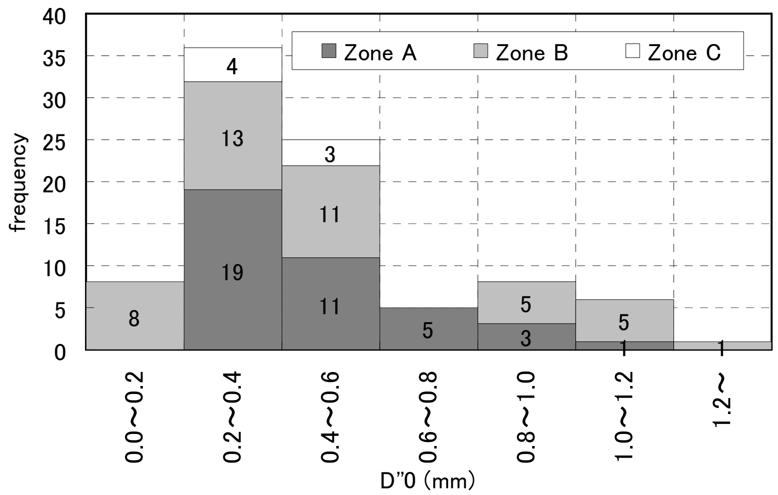

Figure 6: The distribution of deflection

Figure 6 show that the load center deflection (D"0) have highest frequency in 0.2-0.4mm in all the zones. Moreover, “D"0” means the correction value of load and temperature. As compared with “A” and “C” zone, dispersion of “B” zone is large. In “B” zone, because of heavy traffic, pavement tends to get a structural damage, and therefore, it is assumed that the pavement which structural failure has exists a lot.

4 CREDIBILITY OF VISUAL SURVEY

It is important to estimate the credibility of visual survey result against pavement performance analysis with equipments. If correlation of a visual survey result and the result analyzed with equipment is not shown, visual survey method is not helpful to the control of maintenance of pavement.

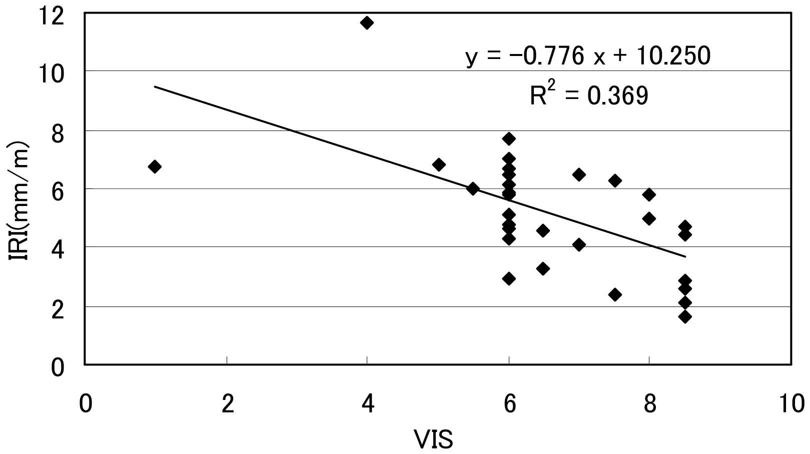

Figure 7: The relation between VIS and IRI

Figure 7 shows the relation between IRI and VIS. Since the damaged pavement is repaired preferentially, a road surface with a small value of VIS hardly exists. Therefore, although deviation is in data, at least we can say that there is some remarkable relation between VIS and IRI because the coefficient of determination was 0.369. Since VIS contains items other than roughness, the value of a coefficient of determination is small.

The relation between VIS and deflection (D"0) is shown in figure 8. It seems that there is no relation between VIS and value of deflection (D"0). It is predicted that although the structural failure of pavement had grown, cut and overlay method was chosen. In this case, diagnosis of the pavement right after repair is very difficult. However, even if the last rehabilitation design was wrong, these results give us useful information of the next rehabilitation plan.

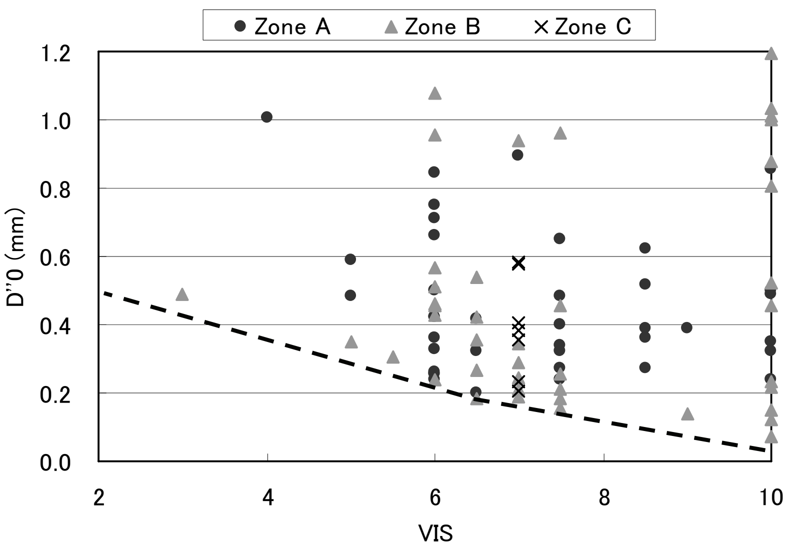

Figure 8: The relation between VIS and deflection

As another observing point, the possibility that the value of deflection (D"0) exists below a dotted line cannot be found. The degree of structural failure of pavement cannot be estimated by VIS. However, VIS is useful if it restrict to evaluating a possibility that the structural failure of pavement has occurred.

5 CONCLUSION

The summary of this study is as follows:

- It is possible to evaluate the surface characteristics by VIS, and it also has correlation with IRI a little.
- In order to estimate IRI in high accuracy, the new visual index which specialized in a degree of comfort is required.
- By contrasting the value of deflection and VIS, useful information in a next rehabilitation plan may be shown.
- VIS shows the possibility of structural failure of pavement. In order to comprehend the structure destructive parts more correctly, continuous visual investigation is required.

REFERENCES

Takayama et al., *Pavement maintenance management system based on visual condition survey*. The 22th Japan Road Conference, 1997

Uesugi et al., *The method of evaluating community roads for asset management system in Yokohama city*. Journal of Pavement Engineering, JSCE VOL.13, 2008