Predicting of Change in Service Life of Rehabilitated Asphalt Pavements based on Measured IRI Before and After Overlay

Dae-Wook Park*, Jose Leo Mission, Soo-Ahn Kwon*****

1. Introduction

In order to maintain the serviceable conditions of highway pavements, maintenance and rehabilitation (M&R) operations are often performed in the form of surface treatments or overlay. In addition to providing smoother pavements, the objective of the (M&R) is to prolong the pavement service life. Data based on the International Roughness Index (IRI) of the profile alone may not provide sufficient information on how much improvement is achieved after M&R. In this paper, predictions of the normalized change in pavement service life are made based on the measured roughness profiles before and after overlay. In this study, nine pavement sections with measured roughness profiles before and after overlay are evaluated to illustrate the concept. Table 1 shows the different rehabilitation methods applied for the respective sections with their roughness profiles shown in Fig. 1 and a comparison of their measured IRI before and after overlay is shown in Fig. 2. The effect of surface profile on predicted dynamic load is determined by vehicle simulation of a two-axle straight truck under different suspension properties and vehicle speeds. The effect of dynamic load variability on predicted pavement life is analyzed by utilizing the predicted tire forces at the rear axle that closely simulates the response of the standard 80kN equivalent single axle load (ESAL). The coefficients of variation (CV) of the predicted dynamic loads are then computed and used in a regression analysis to determine the relationship between dynamic load variability, IRI, and vehicle speed.

2. Coefficient of Dynamic Load Variability and Change in Pavement Life Before and After Overlay

The results of the dynamic simulation have shown that the coefficient of variation (CV) can be related in a linear function to the vehicle speed (V) and profile roughness (IRI) as follows:

$$CV(\%) = A * V(kph) * IRI(m/km) \tag{1}$$

where A is the linear constant that is evaluated as equal to about 0.03 for air-spring suspensions, 0.06 for taper-leaf suspensions, and 0.09 for flat-leaf suspensions, which were evaluated from the average slope (m) of the regression line, that is, $A*V=m$. The lower coefficient in air-spring suspension also means that it has lesser dynamic load variability and is therefore less damaging to the pavement compared to the other suspension types

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* member Kunsan National University Assistant Professor (Email : dpark@kunsan.ac.kr)

** Kunsan National University Assistant Professor (Email : dpark@kunsan.ac.kr)

*** member Korea Institute of Construction Technology(Email : sakwon@kict.re.kr)

(Gillespie et al., 1992). The value of the evaluated linear constant (*A*) is consistent with the average value of 0.041 reported by Fernando (1998) and the form of the linear regression relationship conforms to Sweatman's (1983) finding that the CV is highly correlated with the interaction between roughness and vehicle speed. Figure 4 shows the effect of vehicle speed and suspension type on maximum tire force and coefficient of dynamic load variability (CV).

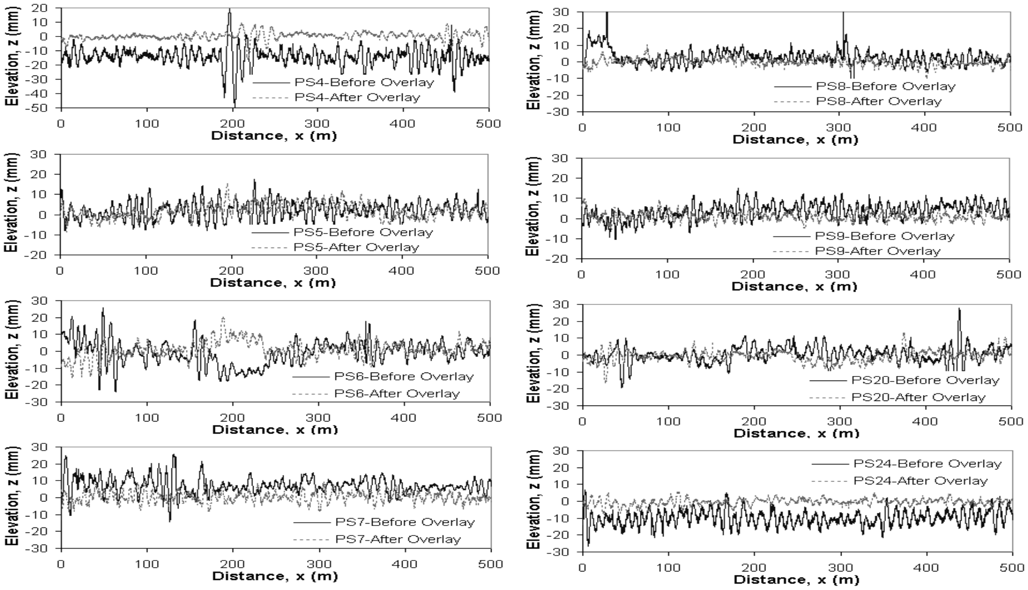


Fig.1. Measured profiles of evaluated pavement sections before and after overlay

Table 1. Pavement rehabilitation method and measured IRI

Pavement Section ID	Rehabilitation Method	IRI (m/km) (Before)	IRI (m/km) (After)
PS4	Grinding (5cm) + 5AC	4.08	1.58
PS5	5AC	2.86	1.91
PS6	5AC	3.28	2.57
PS7	5AC	2.74	2.46
PS8	5AC	2.53	1.55
PS9	5AC	2.58	1.45
PS20	Surface Treatment	2.64	1.66
PS21	Surface Treatment	2.86	1.94
PS24	Grinding (5cm) + PMA	2.98	1.32

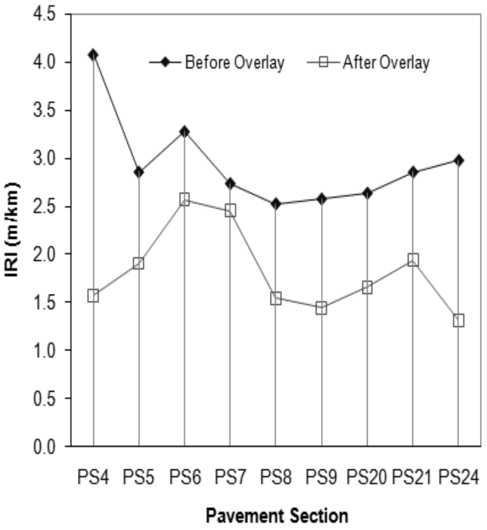


Fig. 2. Measured IRI before and after overlay

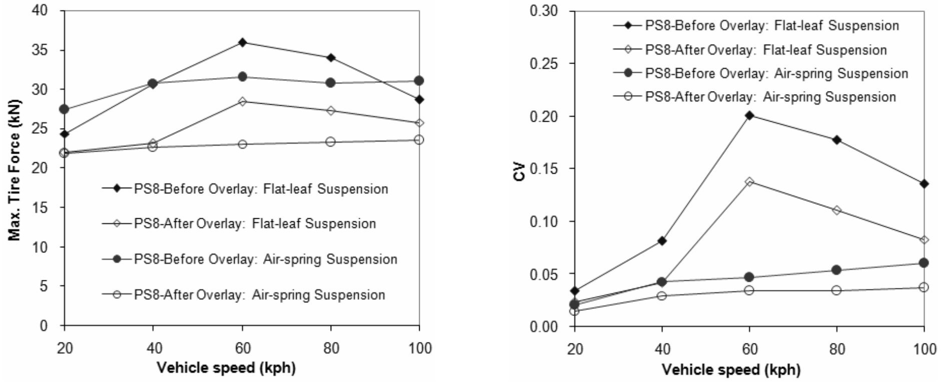
Consequently, for any value of CV for the profile, the acceptability of the surface smoothness may be determined as the difference in the computed pavement damage index (Δ) based on the predicted dynamic load variability CV_a associated with the as-built profile after overlay and the corresponding quantity CV_b determined on the basis of the measured profile before overlay. This is expressed in equation form as follows (Fernando, 1998):

$$\lambda = \Delta_a - \Delta_b = \frac{1}{\left(1 + z * CV_a\right)^n} - \frac{1}{\left(1 + z * CV_b\right)^n} \tag{2}$$

where, Δ_b and Δ_a are defined as the pavement damage index before and after overlay, respectively, λ is the predicted normalized change in pavement life based on the change in profile before and after overlay, *n* is the shear-based fracture parameter or the exponent of the Paris-Erdogan crack growth law with an average value of 3.6, and *z* is the number of standard deviations corresponding to a given percentile of the dynamic load distribution with values of 1.645, 1.282, and 1.037 for the respective confidence levels of 95%, 90%, and 85%. Shown in Fig. 4(a) is the variation of the CV value that was calculated at 95% confidence level, for a 60kph vehicle speed and flat-leaf suspension. In Fig. 4(b), the calculated normalized change in pavement life is compared at different vehicle speeds and flat-leaf suspension for the respective pavement sections. It can be seen from the figure that the rehabilitation method using 5cm grinding plus 5AC overlay (PS4 and PS24) has achieved the highest increase of change in pavement life that is also due to the greater relative change in IRI after overlay compared to the others.

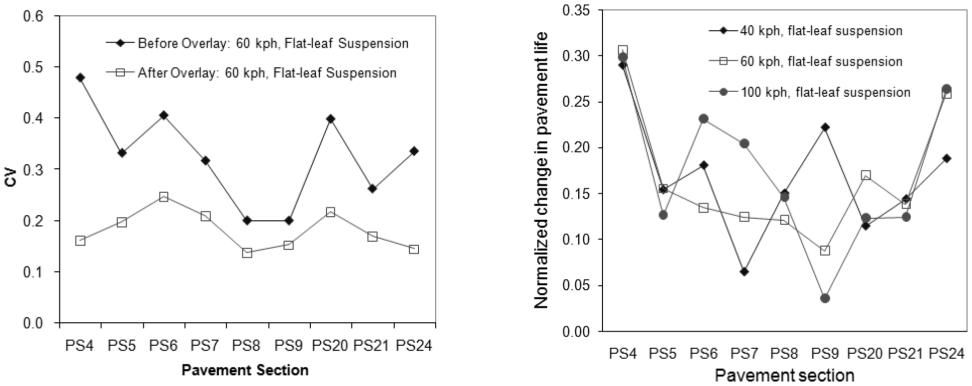
3. Summary and Conclusions

This study has illustrated the method of predicting the normalized change in service life of rehabilitated asphalt concrete pavements based on measured IRI before and after overlay. Nine pavement sections with measured profiles before and after rehabilitation were investigated to establish a relation between the dynamic load variability coefficient (CV) with the pavement roughness (IRI), vehicle speed (V), and suspension type. The results of the study has shown that CV can be related in a linear function to the vehicle speed, IRI, and suspension type, in which it is also shown that air-spring suspensions have lesser dynamic load variability and are therefore less damaging to the pavement compared to other suspensions. Consequently, for any value of CV after the overlay, the normalized change in pavement service life can be predicted based on the change in profile before and after overlay.



(a) (b)

Fig. 3. (a) Effect of vehicle speed and suspension type on maximum tire force, and (b) Effect of vehicle speed and suspension type on coefficient of dynamic load variability CV



(a) (b)

Fig. 4. (a) Calculated CV for various rehabilitated pavement sections: 60kph, flat-leaf suspension, and (b) Calculated normalized change in pavement life at various vehicle speeds: flat-leaf suspension

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