V-4 ENVIRONMENTAL EFFECTS ON PAVEMENT RUTTING

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1. INTRODUCTION

Although modeling pavement deterioration is recognized as one of the most important aspects of managing pavements, achieving it has been a serious challenge. Though it is a well known and acknowledged fact that pavements deteriorate with traffic, time, and environment, the separate or interacting effects of these factors have not yet been clearly defined, especially with the environmental/age effect. This paper presents some findings of the environmental effect on pavement rutting. Previously, traffic loading effects were found to agree with the state-of-the-art understanding i.e. the effect of traffic loading is higher in early stages and decreases with cumulative loading as shown in fig. 1.

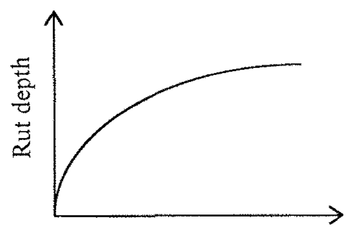


Fig. 1 Trend of Traffic Loading Effect

2. METHODOLOGY

Because of the exposure to climatic cycles i.e. temperature change and water, pavements suffer deterioration over a period of time. Pavement age has been used to represent the cyclic effect of environmental forces contributing to pavement deterioration. For age to actually represent environmental forces, analysis had to be done on data from areas with same climatic conditions. Pavement rut depths data of freeways in Kyushu whose different areas showed no significant climatic differences were used. To obtain the environmental effect alone, elimination of traffic loading effect was achieved by analyzing data of road sections with same traffic loading but different ages. Fig. 2 shows an illustration for obtaining such data from different road sections. To eliminate the influence of pavement structural strength, analysis was done on data from road sections with similar structural strengths. Pavements were divided into 4 groups of structural strengths according to equivalent pavement thickness, T_A and subgrade CBR as were available (Table 1). All data were divided into the 4 structural groups within which analysis was done within different groups of EAL (cumulative traffic loading) as shown in Table2.

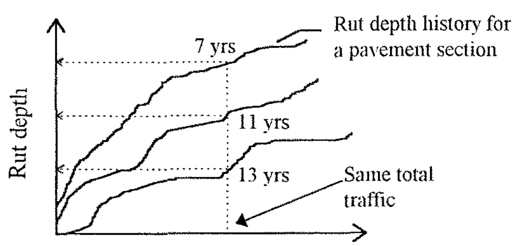


Fig. 2 Illustration of Selection of Data for Analysis

Table 1: Pavement Structural Groups

GROUP	T_A	CBR
A	21.0 - 24.5	8.0 - 10.0
B	21.0 - 24.5	10.5 - 15.0
C	24.5 - 27.0	7.0 - 10.0
D	28.0 - 31.0	4.0 - 8.0

3. RESULTS

After comparing different forms, it was concluded that rutting is affected by environmental forces (age) in an exponential form in which rutting increases more in older pavements i.e. environmental effects become severer with age:

$$RUT = ae^{b(AGE)} \quad (1)$$

The values of a and b for each category are shown in Table 2.

Table 2: Pav. categories and eq. 1 parameters

GR	EAL RANGE	a	b
A	0.6-0.8 mil	5.903	0.05464
	0.7-0.9 mil	7.2348	0.003653
	0.8-1.0 mil	10.1158	0.01355
B	0.4-0.6 mil	7.8312	0.01883
	0.5-0.7 mil	8.509	0.01633
	0.6-0.8 mil	8.5336	0.02352
C	0.6-0.8 mil	6.895	0.02656
	0.8-1.0 mil	7.06	0.02948
	1.4-2.4 mil	8.809	0.02736
	4.2-4.8 mil	11.4067	0.02277
D	1.5-3.0 mil	9.31	0.02808
	2.0-3.5 mil	7.8766	0.04333
	4.0-6.0 mil	9.1889	0.0426
	5.5-6.5 mil	9.725	0.03418

Fig. 3 (a) and (b) depict curves for some categories in the four groups. Preliminary analysis showed that the coefficient a, which represents rut depth at age=0, increased with EAL and the increase was steeper the weaker the pavement (fig. 4). This is because weaker pavements are more likely to develop more rutting due to EAL. b did not show a definite relationship with EAL. Rigorous analysis using stepwise regression gave the following expressions for a and b:

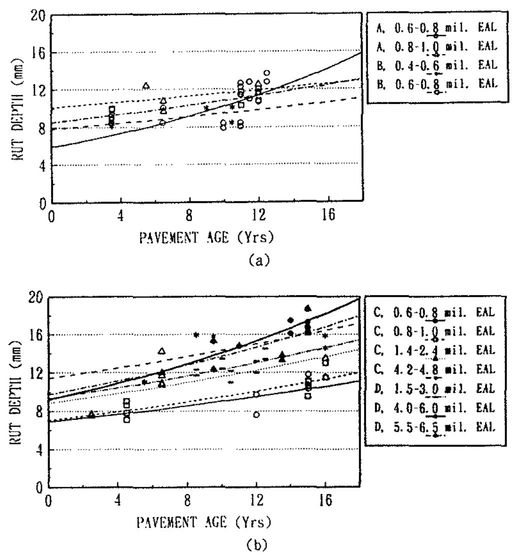
$$a = 8.132 + 0.00333EAL^{0.5} - 0.00024T_A^{\ 3} \qquad (2)$$

s=0.987 R^2=0.64

$$b = 0.0558 - 0.0029CBR \qquad (3)$$

s=0.01 R^2=0.34

All parameters are statistically significant at 5% level. Combining eqns. (1), (2), and (3) gives a complete rut depth prediction equation. The equation gives close values compared with actual rut depths as shown in fig. 5 with r=0.81 and s=1.77 .



Figs.3 Trend of Environmental Effect

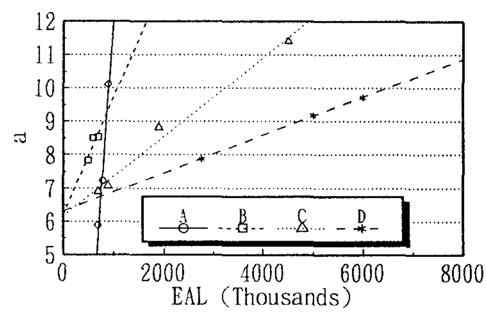


Fig. 4 a vs EAL

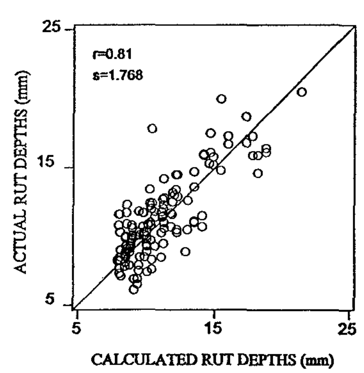


Fig. 5 Actual vs Calculated Rut Depths

4. CONCLUSION

1. Environmental forces follows an exponential function in influencing pavement rutting with older pavements having more rutting. This shows that environmental effects become severer with age.
2. Traffic loading is the main force behind rutting. Looking at figs. 3 or eqn. 1, as a result of traffic loading there is significant rutting at age=0. The opposite is not observed.
3. A complete rutting prediction equation with good accuracy has been established. The equation combines traffic loading and age as separate effects together with T_A and CBR.