DEVELOPMENT OF A TRAFFIC WEAR FACTOR BASED ON AXLE LOAD FREQUENCY AND MAGNITUDE IN AASHO ROAD TEST SKID DATA

C. D. Church
L. F. Holbrook

Research Laboratory Division
Office of Testing and Research
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DEVELOPMENT OF A TRAFFIC WEAR FACTOR BASED ON AXLE LOAD FREQUENCY AND MAGNITUDE IN AASHO ROAD TEST SKID DATA

Working from skid test data developed in special studies conducted in connection with the AASHO Road Test (HRB Special Report 61F, Table 17-A, p. 127), statistical studies have been completed for the purpose of determining to what extent commercial traffic should be included in wear factor computations for rigid and flexible pavement surfaces. "Wear factor" is usually defined in terms of pavement age and rate of traffic flow. Reliable wear factor values have considerable significance in predicting pavement performance and particularly in estimating slipperiness of pavements.

Least-square best fit lines were fitted to the AASHO data regarding coefficient of friction, μ, and frequency of axle application, f. For this study, tandem axle loads were converted to single loads, thus doubling the applications. This was done separately for new concrete and bituminous surfaces, to obtain the slopes where the rate of change is most critical. This critical region was defined as the first million axle applications as determined by graphical inspection. Exponential decay curves were tried but it was found that consequent analysis would result in formulas too complicated for practical use. Plots of three representative lines were made depicting the extreme and mid-range lines for both types of pavement for the various loads used in the test (Fig. 1), to show the trend exhibited by increasing axle loads.

Scatter plots of the rate of wear (slopes, $\frac{\Delta\mu}{\Delta f}$) vs. load were then made for each surface type using each axle load (Fig. 2) in order to assess any relation between these two variables. When the initial theoretical condition of zero slope for zero load was included, the configuration indicated that a logarithmic functional relationship of the type

$$y = A \ln (x + 1)^*$$

would best fit the scatter plot. Curves of this type were fitted by least squares to the scatter plot (Fig. 2). Correlation coefficients and the standard error of estimate were computed and are given on the graphs. The correlation coefficient values seem to justify the logarithmic curve as a best estimate line since they are greater than those produced by a straight line. The slight discrepancy in the percentage of items falling within the one standard error band from the ideal (66.66 percent) is due to data discreteness (accentuated by the small sample size) and the fact that other statistical assumptions may not be entirely met, a condition often encountered in analysis of this type.

* This particular form was chosen because the curve must pass through (0, 0).

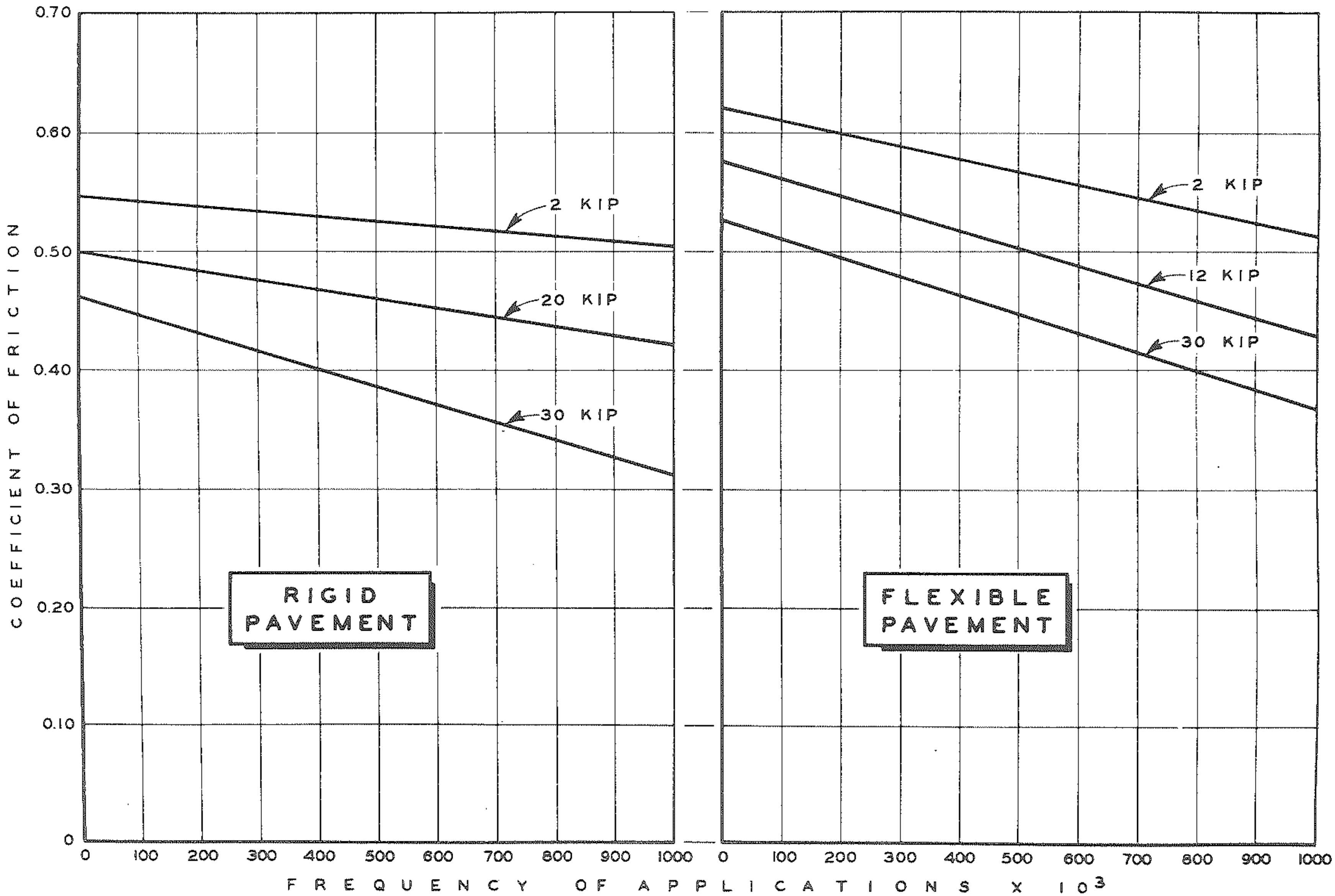

Figure 1. Least-square fitted lines of coefficient of friction versus frequency of applications of various single axle loads. Curves represent high, medium, and low ranges for respective pavement types.

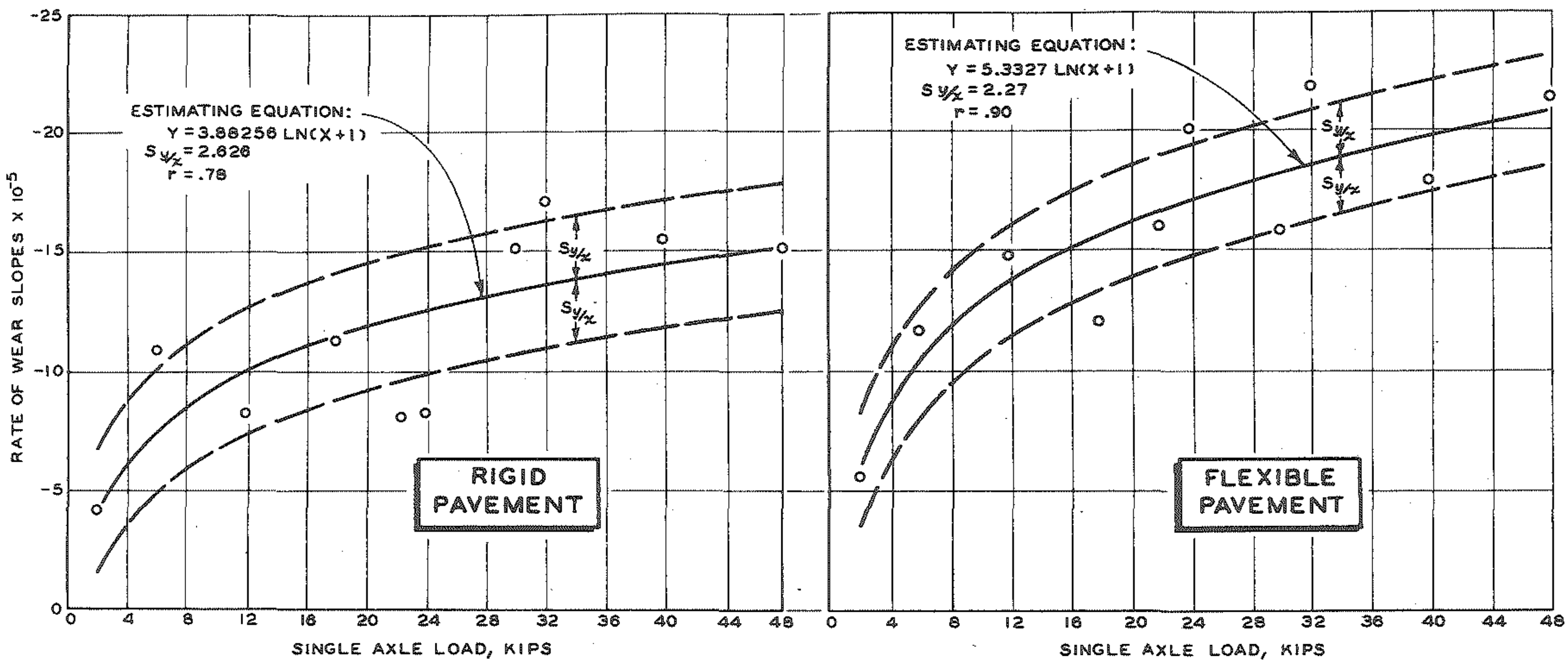

Figure 2. Logarithmic curves fitted to scatter plots of load versus slope.

Using ratios of values given by the estimating equations (Fig. 2) for given loads to the 18-kip point of the equation, a relationship of load and rate of wear was found. Since the concrete and bituminous curves were very nearly identical, they were combined (Fig. 3). This similarity indicates that even though the rate of wear is different for each type of surface, the rates are nearly the same in terms of the 18-kip rates.

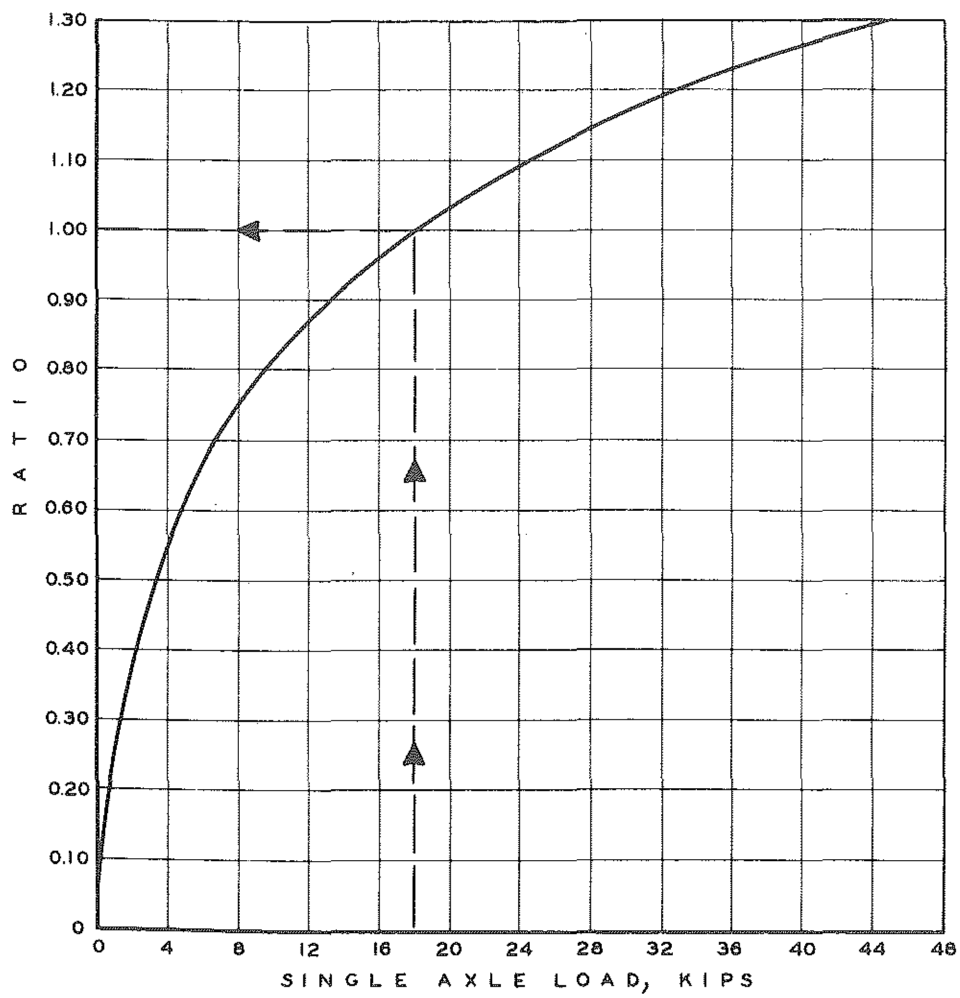

Figure 3. Ratios of the slopes of various loads to 18-kip slope for both rigid and flexible pavements.

As a result the following wear factor equation was developed:

$$WF = \frac{A\ (2 \times 1000\ R_p N_p + N_c \sum_{i=1}^{k} f_i R_i)}{1000} \tag{1}$$

where:

A = age of pavement in years
N_p = average daily volume for passenger cars during period $\underline{A}$
R_p = 18-kip wear equivalent for passenger cars (Fig. 3)
N_c = average daily volume of commercial vehicles in thousands during period $\underline{A}$
f_i = number of axles per 1000 commercial vehicles for $\underline{i}$-th load category during period $\underline{A}$
R_i = 18-kip wear equivalent factor for $\underline{i}$-th load category (Fig. 3)
k = number of axle load categories determined from loadometer studies.

This equation was applied using 1959 and 1960 Michigan Loadometer Survey data (with 3.8 kips assigned as a reasonable weight for a loaded passenger vehicle). The results indicated that the relationship expressed by Eq. 1 could be further simplified to the following form:

$$WF \doteq \frac{A\ (N_p + 3N_c)}{1000} \tag{2}$$

A sample calculation using Eq. 1 would be computed as follows, demonstrating the appropriateness of the simplified form of Eq. 2. Using a sample of data from the 1960 Michigan Loadometer Survey, the following value was found: $\sum_{i=1}^{k} f_i R_i = 2043$, where the $\underline{R_i}$ values are taken from Fig. 3 for the various k load categories and the $\underline{f_i}$ values (the number of axles per 1000 commercial vehicles for a specific load category) taken from the Loadometer data. With 3.8 kips (1.9 kips per axle) as the passenger car weight, R_p = 0.34 (also taken from Fig. 3). After multiplying R_p by its coefficients and substituting these values into Eq. 1, one has:

$$WF = \frac{A\ (680\ N_p + 2043\ N_c)}{1000}$$

or

$$WF \doteq \frac{A\ (N_p + 3\ N_c)}{1000}$$

which is Eq. 2, the number 1000 being simply a constant to reduce the magnitude of the final figure.

Upon further substitution, with A = 7 years, N_p = 800 and N_c = 200 (assuming 20 percent commercial traffic and an ADT of 1000), a characteristic Wear Factor value results:

$$WF \doteq \frac{A\ (N_p + 3\ N_c)}{1000}$$

$$\doteq \frac{7\ (800 + 600)}{1000}$$

$$\doteq 9.8$$

This resulting value of 9.8 is meaningless when considered by itself, since it is only a relative value and would have to be compared with other, similarly computed wear factors.

It must be borne in mind that this equation is developed using the assumption that the axle frequency for a given load category expressed in percent, does not vary appreciably with time or location. Thus, for any one location the ratio of the number of axles in a given load category to the total number of axles remains approximately the same, and also the ratio does not vary with location. The results of Michigan studies currently in progress should indicate if this assumption is warranted.