pressuremeter parameter in the well-established Transport Canada design chart (Figure 9).

The multilayer elastic design method makes a more thorough use of the moduli profile obtained with the pavement pressuremeter than does the chart design procedure. The multilayer elastic design is therefore recommended. In the examples quoted in the text the calculated strains were probably larger than they should be. The overestimation of strain was attributed to the fact that the pressuremeter modulus is measured at strain levels that are larger than the strains developed by the wheel load. Recently a means of obtaining pressuremeter moduli at much lower volumetric strains has been devised, and the method will be the subject of another article.

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Load Equivalency Factors of Triaxle Loading for Flexible Pavements

M.C. WANG AND R.P. ANDERSON

This paper presents the load equivalency factors of triaxle loading for flexible pavements. Two different approaches were used to determine load equivalency factors—American Association of State Highway Officials' (AASHO) empirical and mechanistic approaches. AASHO's empirical approach was used first to determine the load equivalency factor of 338-kN (76-kip) triaxle loading. For this approach, experimental pavements were subjected to approximately 55 000 repetitions of 338-kN triaxle loading. The load equivalency factor determined was 2.60 for the range of structural numbers studied and for a terminal serviceability index of about 2.0. The mechanistic approach was used in order to include a broad range of triaxle loading intensity. For this approach, the maximum vertical compressive strain on the top of the subgrade was analyzed by using the bitumen-structures-analysis-in-roads (BISAR) computer program. The maximum subgrade compressive strains were related with load equivalency factors in logarithmic coordinates for single- and tandem-axle loadings. The relation for triaxle loading was established by first plotting the equivalency factor determined from the AASHO approach against the maximum subgrade strain. Then a line was drawn through this point parallel to the lines of single- and tandem-axle loads. The load equivalency factors of various triaxle loading intensities were then obtained by entering the maximum subgrade strain of each load intensity into the relation.

One of the most important tasks of highway officials and engineers is the maintenance of the deteriorating, existing highway system. The deterioration of the highway network is augmented by the continued growth of traffic and the accompanying increase in vehicle size and gross weight in an attempt to improve the energy savings and economic efficiency of the transportation system. In order to maintain the heavy gross vehicle weight and still stay within legal axle-to-axle load restrictions, the trucking industry has devised the triaxle or triple-axle configuration. The most common adaptation of this new axle arrangement is the rear assemblage of the familiar single-unit, four-axle coal trucks, although five-axle tractor-semitrailer units that have triaxle configurations are becoming more commonplace.

Highway engineers are concerned about the impact of the innovative heavy triaxle vehicles. Unfortunately, results of the American Association of State Highway Officials (AASHO) road test (1) do not include information that would permit an assessment of the structural damage caused by triaxle vehicles. Consequently, incorporation of triaxle loading into design formulas is not possible. Additional work is necessary to determine the relative destructive effect of heavy triaxle configuration and allow for its application to pavement design and rehabilitation schemes.

One method of assessing the destructive effect of triaxle loading is through the use of the concept of load equivalency factor. The load equivalency factor of a given axle loading is defined as the number

of applications of a standard load that is equivalent in destructive effect to one application of the load under consideration; 80-kN (18-kip) single-axle load is normally used as the standard load. This paper presents the methods of evaluation and the results of load equivalency factors of triaxle loading for flexible pavements.

EVALUATION METHODS

The concept of load equivalency factor is from the AASHO road test (1). The criterion used in the AASHO road test for determination of load equivalency factor is serviceability. At the AASHO road test, equivalency factors were determined for two standard axle configurations: the single axle and the tandem axle, with single-axle load magnitudes up to 178 kN (40 kip) and tandem-axle loads up to 213 kN (48 kip). Since extrapolation from results of earlier tests is not reasonable, establishment of equivalencies for axle configurations not considered in these tests necessitates performance data collected under controlled environments.

Because prototype pavement studies that involve new axle-load configurations are time consuming and costly, analytical methods that use mechanistic approaches to the equivalency determination have received the most attention recently. Among the more noteworthy studies are those of Deacon (2); Treybig and Von Quintus (3); Hicks, Layton, and Glover (4); Terrel and Rimsritong (5); and Kingham (6). These analytical methods use two different modes of pavement distress (fatigue cracking and rutting) rather than pavement serviceability as the criteria for determining equivalency factors. In the analysis, the fatigue mode of distress was related with the maximum tensile strain at the bottom of the stabilized layer; rutting was related with the maximum compressive strain at the top of the subgrade. In their analysis, Treybig and Von Quintus (3) also developed a method by which the maximum compressive strain on the top of the subgrade could possibly be used to extrapolate the load equivalency factors determined at the AASHO road test. This method is based on the assumption that the relation between the maximum compressive strains on the top of the subgrade and the load equivalency factors is unique regardless of the type of axle configurations.

The mechanistic approach either considers only one distress mode at a time or requires assumptions that are not verifiable at this time. These inherent limitations make it very difficult to use the mechanistic approach alone to generate load equivalency factors that are compatible with those developed at the AASHO road test. Therefore, the empirical approach by using pavement performance data is necessary for determination of equivalency factors for triaxle loading. Current economic conditions, however, dictate that the conduct of a full-scale load test similar in scale to the AASHO road test for developing equivalency factors for a spectrum of triaxle loading is infeasible. Therefore, for this research, both empirical and mechanistic approaches were adopted. Specifically, the empirical approach was used to determine the equivalency factor of 338-kN (76-kip) triaxle loading, whereas the mechanistic approach was employed to include a broader range of load intensity for the triple-axle configuration. The 338-kN load intensity was selected on the basis of weigh station data collected in Pennsylvania.

LOADING CONDITION

Loading condition is one of the most important variables that affects the generated load equivalency factors. Conditions that should be considered are load magnitude, axle-load distributions, axle spacing, tire types, tire pressures, and tire spacings.

Magnitude of Load

To obtain a range of the triaxle load that operates on Pennsylvania highways, records from weigh stations were acquired through the Pennsylvania Department of Transportation. According to these data, the triaxle weights varied between 107 and 291 kN (24 and 65.5 kip) with a mean of 80 ±5.8 kN (55 ±1.3 kip). Note, however, that these data were collected at selected weigh stations throughout the state. The difficulty in obtaining an accurate picture of the loads that are actually being hauled, especially in the coalbelt areas, has long been acknowledged. On the basis of this observation, together with recognition of the increasing demand of heavier axle loads, a load range considerably higher than that indicated by the weigh station summaries was adopted in this study. Loads selected were 200, 245, 289, 334, and 378 kN (45, 55, 65, 75, and 85 kip). This range is believed to be sufficiently comprehensive to draw accurate conclusions about the damaging effect of the triaxle configuration.

In addition to the five triaxle loads and the standard 80-kN (18-kip) single-axle load, three other single-axle loads--27, 53, and 107 kN (6, 12, and 24 kip)--and four tandem-axle loads--80, 116, 151, and 187 kN (18, 26, 34, and 42 kip)--were investigated to compare the generated equivalency factors and the equivalency factors developed at the AASHO road test.

Axle Load Distribution

In all previous work involving calculation of triaxle equivalencies [e.g., Treybig and Von Quintus (3), Hicks and others (4), and Terrel and Rimsritong (5)] no mention is made of what axle-by-axle weight distribution was used in the analysis. Therefore, in these studies we must assume that for triaxles this weight is equally distributed among the three axles in the configuration. Although this assumption appears reasonable for tandem axles, it may not be in the case of triaxles. Note that the tandem axle is a fixed configuration, whereas triaxles typically have two fixed axles and one lift axle. Indeed, a majority of triaxles are essentially modified tandem axles with either a lift axle ahead of or behind the tandem. On triaxle dump trucks, this axle is usually ahead of the tandem, whereas on concrete mixers and specialized vehicles it is not uncommon for the lift axle to follow the tandem set.

Pressure in the lift axle may be regulated by the operator (lift systems are controlled by pneumatic or hydraulic pressures) so that the load carried by this axle (and also others in the tridem) may vary considerably. Therefore, distribution of the load (axle by axle) in the tridem is a function of the lift-axle air pressure.

The data from the weigh stations were analyzed to determine whether a typical weight distribution existed among axles in the tridem sets. Although the mean weights for each axle in the set resulted in a weight distribution relation of approximately 1/4, 3/8, and 3/8 for the lift axle, second, and third axles, respectively, these proportions did not hold true for the large majority of individual cases. A statistical regression of proportionate weights on gross triaxle weights likewise yielded no typical axle-by-axle weight that could be used in the loading condition for evaluation of triaxle equivalencies for various load magnitudes. Therefore, since no quantifiable relations could be obtained from

field data regarding the distribution of weight among axles of the tridem set, the assumption of equal weight distribution was adopted in this study for triaxles as well as for tandems.

Axle Spacing

A variety of tandem-axle and triple-axle spacings have been used throughout the literature. For instance, Deacon (2) considered tandem-axle spacings of 91.4, 121.9, and 152.4 cm (36, 48, and 60 in). He recommended the 121.9-cm (48-in) spacing for theoretical work with the caution that axle spacing becomes more critical in terms of its effect on pavement response parameters as the modulus of the stabilized layer increases. Treybig and Von Quintus (3) used a tandem-axle spacing of 127 cm (50 in) and a triple-axle spacing of 136 cm (54 in) in their equivalency factor study. (Why these spacings should not be equal was not explained.) Uzan and Wiseman (7) investigated equivalencies for three different axle spacings of 102.9, 121.9, and 141.0 cm (40.5, 48, and 55.5 in). Since a majority of triaxles are essentially modified tandems, a different spacing for the two-axle configurations does not appear to be justified. Therefore, in this study, an axle spacing of 124 cm (49 in) was used for both tandem axles and triple axles.

Tire Types, Air Pressures, and Spacings

A number of methods for selecting contact areas and pressures for loading input have been used. Treybig and Von Quintus (3) divided tire pressures into four groups that encompass all loads. For gross weights from 27 to 245 kN (6000 to 55 000 lbf), tire pressures were assumed to be 517.5 kPa (75 lb/in^2), and for the range from 245 to 400 kN (55 000 to 90 000 lbf), tire pressures of 552 kPa (80 lb/in^2) were assumed. Terrel (5) assumed that the contact radius is half of the tire width, and he varied the tire or contact pressure to account for changes in the magnitude of the wheel load. This approach yields contact pressures as high as 1097 kPa (159 lb/in^2) for 20.3-cm (8-in) wide tires and as low as 152 kPa (22 lb/in^2) for 47.0-cm (18.5-in) wide flotation tires. But, the majority of researchers, including Uzan and Wiseman (7), use a constant contact radius throughout a spectrum of tire load magnitudes and vary the pressure to account for this difference. This method often gives higher-than-normal tire pressures for heavy cargoes.

A more rational approach for simulating tire loads was undertaken here. Since allowable tire load and tire inflation pressure are a function of tire type, the corresponding inputs required in the analysis are also functions of the type of tire selected. According to the 1978 tire guide (8), the most popular heavy truck tire is the 10.00-20 bias-ply tire, and the second most popular heavy truck tire is the 10.00-22 and its radial equivalent, the 11-24.5 tire. On the basis of this information, all axle loads for which the 10.00-20 bias-ply duals are acceptable were assumed to be carried by these types of tires. If axle loads (and consequently tire loads) exceeded the recommended load limits for the 10.00-20 tire size designation, then the next-popular size tire (10.00-22) was assumed to carry the load. In all cases, the tire inflation pressure that corresponded to the minimum-load range recommended for the particular tire load was used. This information can be extracted from the standards for tire load limits at various inflation pressures as set by the Tire and Rim Association (9).

The spacing of dual tires is dependent on the tire size selected to carry the various axle loads. In most of the previous studies on theoretical equivalency factors, including those by Deacon (2) and Treybig and Von Quintus (3), spacing of dual tires was assumed to be a linear multiple of the equivalent contact radius. Deacon selected dual spacings of 2.5, 3.0, and 3.5 times the contact radius of one tire in the dual set. His results show that the maximum principal tensile strains developed on the bottom of the pavement surface layer are significantly affected by dual-tire spacing, whereas the equivalency factors generated by a fatigue cracking criterion were not as affected by such spacing. Since fatigue cracking is but one of the criteria used to develop equivalencies in this study, a similar lack of variance in equivalency factors developed through the other criteria cannot be readily assumed. Furthermore, the selection of a spacing that varies with the contact area (and hence the wheel load and the axle load) adds another variable that could be a source of considerable discrepancy when comparing equivalencies calculated by using different evaluation criteria. Therefore, a constant dual-tire spacing was adopted in this study. The spacing selected for all dual tires considered here is 33 cm (13.0 in). This distance is the minimum recommended by the Tire and Rim Association [adopted by Goodyear (10)] for 28-cm (11.00-in) nominal width tires installed on 20.3-cm (8.0-in) design rims. The minimum spacing recommended for 25.4-cm (10.00-in) nominal width tires is 31.8 cm (12.5 in). The additional 1.3 cm (0.5 in) is assumed to be a reasonable allowance for proper air circulation and dissipation of tire heat as well as avoidance of the sidewall contact caused by the heavier axle loads.

A summary of the adopted loading conditions is presented in Table 1. The results are expressed in terms of calculations performed for bias-ply tires rather than for the less common radial tires. In all cases, axle loads are assumed to be equally distributed among the 4, 8, and 12 tires of the single, tandem, and triple axles, respectively.

On the basis of these loading conditions, a triaxle trailer was fabricated for field testing. Figure 1 shows the vehicle, and Figure 2 illustrates the axle spacing and the axle load distribution. The total load on the triple axle was 338 kN (76 kip) with a distribution of 31.5, 33.7, and 34.7 percent for the first, second, and third axle, respectively. This load intensity was selected to simulate the highest load possible by using the test trailer and the available steel ingots as lading. Also, because of the size and shape of the steel ingots, this load distribution was considered close enough to the equal distribution assumed above.

EXPERIMENTAL PAVEMENTS

The experimental pavements are part of the Pennsylvania Transportation Research Facility, which is a single-lane, oval-shaped, full-scale experimental highway 1.6 km (1 mile) in length. The facility consists of 21 sections that have different compositions, layer thicknesses, and lengths, as shown in Figure 3. These sections had been subjected to axle loads applied by a conventional single-axle tractor pulling a semitrailer and one full single-axle trailer before triaxle loading was applied. The actual axle loads that were applied were converted to equivalent 80-kN (18-kip) single-axle loads (EAL) by using AASHO-derived equivalency factors. The triaxle loading was applied by using the original single-axle tractor pulling the triaxle trailer shown in Figure 1. A total of 55 000 repetitions of 338-kN (76-kip) triaxle loading was applied to the test pavements.

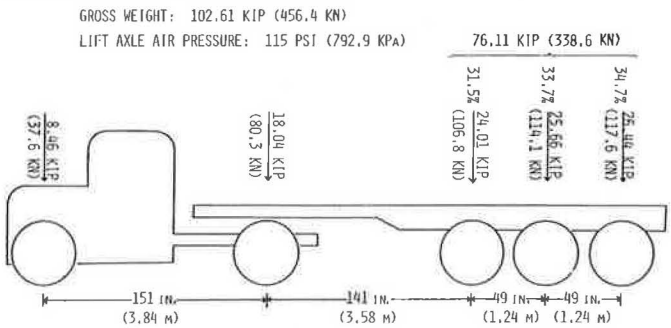
Table 1. Loading conditions used.

Axle Configuration[a]	Total Load (kN)	Wheel Load (kN)	Tire Size	Load Range	Tire Pressure (kPa)	Contact Radius (cm)
Single	26.7	6.7	10.00-20	F	517.1	6.40
	53.4	13.4	10.00-20	F	517.1	9.07
	80.1	20.0	10.00-20	F	517.1	11.10
	106.9	26.7	10.00-22	H	724.0	10.82
Tandem[b]	80.1	10.0	10.00-20	F	517.1	7.85
	115.8	14.5	10.00-20	F	517.1	9.42
	151.4	18.9	10.00-20	F	517.1	10.80
	187.0	23.4	10.00-20	G	620.6	10.95
Triple[b]	200.3	16.7	10.00-20	F	517.1	10.13
	244.9	20.4	10.00-20	F	517.1	11.20
	289.4	24.1	10.00-20	H	724.0	10.29
	333.9	27.8	10.00-22	H	724.0	11.05
	378.4	31.5	11.00-24	H	724.0	11.76

Note: 1 kN = 0.225 kip; 1 kPa = 0.145 lb/in^2; and 1 cm = 0.394 in.
[a]Center-to-center dual-tire spacing = 33 cm (13 in) for all conditions.
[b]Axle spacing = 124 cm (49 in).

Figure 1. Triaxle trailer used for loading.

Figure 2. Sketch of test vehicle.



FIELD TESTING

Throughout the axle-loading history, rut depth was measured biweekly every 12.2 m (40 ft) in both wheelpaths. Surface cracking was surveyed and mapped biweekly. Surface roughness was measured in both wheelpaths by using a MacBeth profilograph. The roughness factors obtained from the profilograph data were converted into the present serviceability index (PSI) of the pavement by using the following equations:

$$PSI = 11.33 - 4.06(\log RF) - 0.01\sqrt{C + P} - 0.21\,\overline{RD}^2 \quad (1)$$

$$RF = 63.267 + 0.686\,R \quad (2)$$

where

PSI = present serviceability index,
RF = Mays meter roughness factor,
C = area of cracking (m²/1000 m²),
P = area of patching (m²/1000 m²),
$\overline{RD}$ = rut depth (cm), and
R = profilograph reading (cm/km).

In addition, surface deflections, profile of the pavement temperature, distribution of the subgrade moisture, and weather data were collected. Detailed information on field testing is available elsewhere (11,12).

LOAD EQUIVALENCY FACTORS

As stated before, the load equivalency factors of triaxle loading were determined by using both the AASHO empirical approach and the mechanistic approach. The AASHO approach was used to compute the equivalency factor of 338-kN (76-kip) triaxle loading only, whereas the mechanistic approach was used to consider a spectrum of triaxle loading of various intensities.

AASHO Empirical Approach

Of the 21 test pavements at the research facility, only 12 pavements were not overlaid, surface treated, or reconstructed, and they produced PSI data for both 80-kN (18-kip) single-axle loading and 338-kN (76-kip) triaxle loading. The 55 000 repetitions of 338-kN triaxle loading, however, were not sufficient to induce a noticeable decrease in PSI for 7 of the 12 pavements. Consequently, only 5 pavements (sections 8, B, E, F, and G) provided PSI data useful for computing the load equivalency factor of 338-kN triaxle loading. Figures 4 and 5 illustrate the PSI data of section 8 for 80-kN EAL and 338-kN triaxle loading, respectively. Data for other sections are documented elsewhere (13). From these PSI data, the loading equivalency factor can be computed as follows:

$$E_{f_{76}} = (N_{18}/N_{76}) - C_f \quad (3)$$

where

$E_{f_{76}}$ = load equivalency factor for 338-kN (76-kip) triaxle loading,
N_{18} = number of 80-kN (18-kip) single equivalent axle loading required to cause a PSI drop of ΔPSI,
N_{76} = number of 338-kN (76-kip) triple-axle loading required to cause ΔPSI, and
C_f = correction factor equal to the sum of the load equivalency factors of the test vehicle's steering and drive axles.

Figure 3. Plan and profile of experimental pavements.

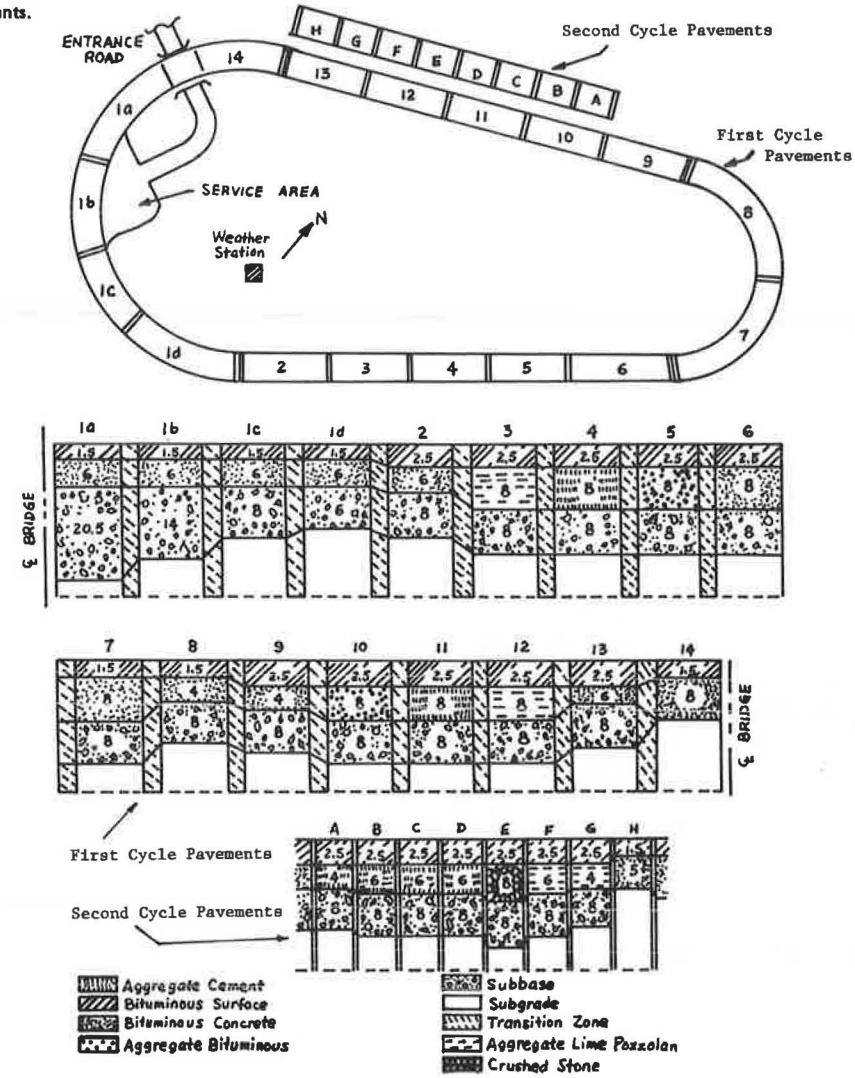


Figure 4. Performance curves for 80-kN EAL, section 8.

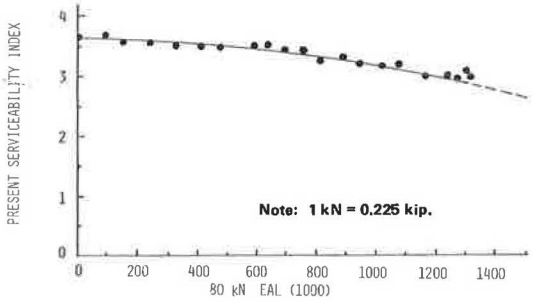


Figure 5. Performance curve for 338-kN triaxle loading, section 8.

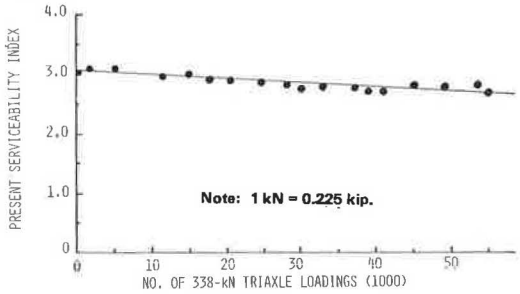
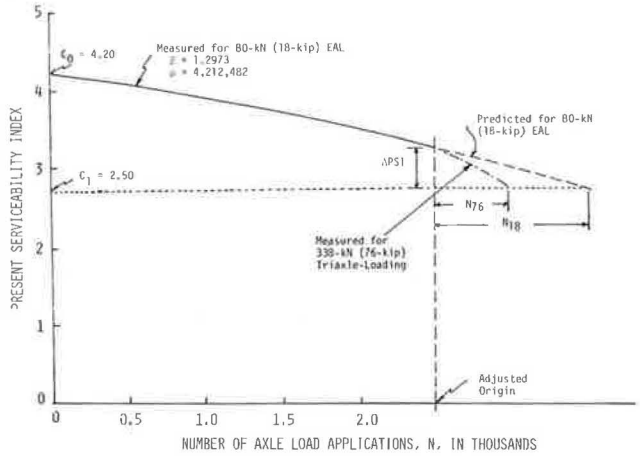


Figure 6. Rationale for calculation of load equivalency factor from pavement performance data.



The rationale for this calculation is illustrated in Figure 6. The loading intensities on the test vehicle's steering and drive axles were 37.6 kN (8.46 kip) and 80.3 kN (18.04 kip), respectively, as shown in Figure 2. The load equivalency factors for these two axle loads were 0.04 and 1.00, respec-

tively. Therefore, the correction factor (C_f) equals 1.04.

The predicted PSI curve for 80-kN EALs shown in Figure 6 was obtained by fitting the data points to the AASHO equation in which the serviceability loss is a power function of axle load applications. This power function may be expressed in terms of β and ρ, defined under Equation 4, below.

$$G_t = \beta(\log W_t - \log \rho) \quad (4)$$

where

G_t = a function (the logarithm) of the ratio of loss in serviceability at time t to the potential loss taken to a point where p_t = 1.5,
β = a function of design and load variables that influence the shape of the serviceability curve,
W_t = axle load applications at the end of time t,
ρ = a function of design and load variables that denotes the expected number of axle load applications to a serviceability index of 1.5, and
p_t = serviceability at the end of time t.

Figure 5 shows that, in the approximately 55 000 applications of 338-kN triaxle loading, PSI values of all five test pavements decreased almost linearly with the number of axle load applications. Therefore, a linear extrapolation was used, when necessary, in the computation of load equivalency factors. To avoid extrapolating too far from the range of the available data, a PSI drop of 0.50 was used to compute load equivalency factors. For this PSI drop, the terminal serviceability index values on which the computation was based differed among sections: They were 2.45, 2.30, 1.83, 2.25, and 2.00, for sections 8, B, E, F, and G, respectively. Results of the computation are presented in terms of structural number in Figure 7. The data points fluctuate, and no apparent trend on the variation of load equivalency factors with structural number is seen. For the range of structural numbers studied, the load equivalency factor for 338-kN triaxle loading equals approximately 2.60.

Mechanistic Approach

The mechanistic approach was used to extend the preceding results to a broad range of triaxle loading intensity. According to Treybig and Von Quintus (3), the equivalency factors of triaxle loading may be determined by using the relation between the maximum vertical compressive strain on the top of the subgrade and the equivalency factors of single-axle loading, since the equivalency factors of tandem-axle loading that were determined by using this relation were close to the AASHO equivalency factors. Note that this relationship was developed for flexible pavements similar to some of the pavements at the AASHO road test and that no statistical tests were presented. In all cases, the pavements modeled in the computer program (ELSYM 5) consisted of granular (nonstabilized) base courses. Therefore, new relations for flexible pavements that contain stabilized base courses should be established, and statistical tests should be performed to assess the dependability of the established relationships.

Initially, both single- and tandem-axle loadings were input as the loading conditions to compute the maximum vertical compressive strains on the top of the subgrade. The computations were made by using the bitumen-structures-analysis-in-roads (BISAR) computer program (14) and the material properties are presented in Table 2. Details on the determination of material properties are reported elsewhere (15). AASHO equivalency factors for these loads were then calculated for a terminal serviceability index (p_t) of 2.0. For each pavement section analyzed, logarithmic transformations of both the maximum vertical compressive subgrade strain and the calculated AASHO load equivalency factor (E.F.) for each axle load configuration were obtained. A least-squares-regression analysis of log (ε_V) versus log (E.F.) was then performed by using MINITAB II (16).

Plots of both the single- and the tandem-axle load equivalency factor relations for section 1C are given in Figure 8 as an example. According to the results of the analysis, the two log (ε_V) versus log (E.F.) relations may be parallel but are not necessarily colinear. From a statistical standpoint, this discrepancy makes it impossible to predict triaxle equivalencies because a similar relationship for triples cannot be defined. This conclusion may not hold true if error about the inputted AASHO equivalencies is considered. Recall that the equivalencies used in these relations were not measured but rather calculated by using a regression function that was derived from an analysis of AASHO road test sections. Indeed, since subgrade compressive strains were determined directly from elastic layer theory, neither ordinate nor abscissa in the log (ε_V) versus log (E.F.) relations in these analyses has error. This lack of error and the existence of a functional relation between the logarithmic transforms of load and the mechanistic pavement strain account for the exact correlation between Y and X in these relations. Nevertheless, in lieu of additional information, the analyses show that the relations for load equivalency factors are

Figure 7. Load equivalency factor of 338-kN triaxle loading.

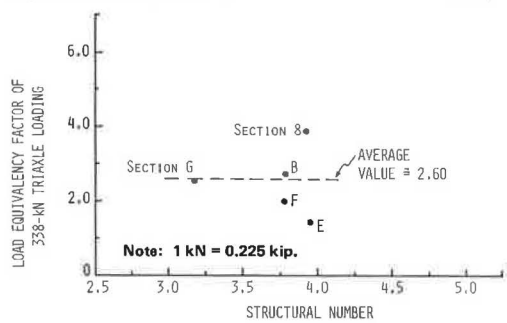


Table 2. Elastic constants of pavement materials.

Layer Description	Elastic Modulus (MPa)	Poisson's Ratio
Surface course		
Asphalt concrete, Spring	966	0.40
Asphalt concrete, Summer	186	0.40
Base course		
Bituminous concrete (BCBC), Spring		
Top sublayer	2 207	0.35
Bottom sublayer	3 034	0.35
BCBC, Summer		
Top sublayer	138	0.35
Bottom sublayer	262	0.35
Aggregate-lime-pozzolan (ALP), Spring	16 552	0.15
Limestone aggregate cement (LAC), Spring	24 828	0.20
Granular subbase, Spring	331	0.40
Subgrade, Spring	55	0.45

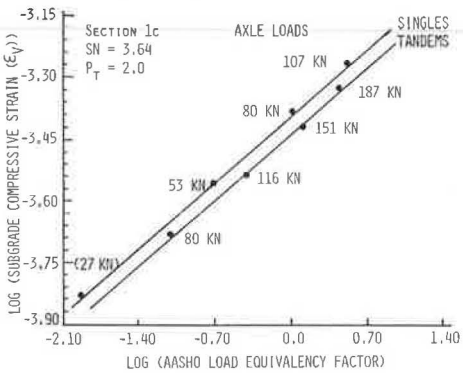
Notes: 1 MPa = 145 lbf/in^2.
Evaluations are for initial pavement conditions.

different for single axles and tandem axles, and, therefore, one cannot predict triaxle equivalencies from the relations of single or tandem axles.

It is possible, however, to establish the relation between the maximum vertical subgrade strains and the load equivalency factors for triaxle loading by using the trend of the relations for single- and tandem-axle loadings together with the load equivalency factor (2.60) of 338-kN (76-kip) triaxle loading. This is accomplished by first plotting the load equivalency factor of 2.60 against the maximum subgrade strain for 338-kN triaxle loading, and then drawing a straight line through this point parallel to the lines for single- and tandem-axle loads. Relations are established for pavement sections B, E, 4, and 6 and are presented in Figures 9 and 10. For section 6, the analysis was made for three seasons so that the possible seasonal effect, if any, on load equivalency factors could be observed.

From this newly established relation, the load equivalency factors for various intensities of triaxle loading can be obtained by entering into this line the maximum vertical subgrade strain corresponding to each loading intensity. Results of the computation are tabulated in Table 3. Note that, on the basis of the semiempirical approach, the load equivalency factors did not vary with seasons, as Figure 10 illustrates. This is consistent with AASHO's results. Furthermore, the slight difference in load equivalency factors of triaxle loading between sections, as shown in Table 3, was primarily due to error involved in reading numbers from Figures 9 and 10. Rigorously speaking, this discrepancy should not exist because the equivalency factor (2.60) of 338-kN triaxle loading is assumed to be constant with respect to structural number within the range of conditions studied.

Figure 8. Relation between maximum subgrade compressive strain and AASHO load equivalency factors.



Note: 1 kN = 0.225 kip.

Figure 9. Subgrade compressive strain versus load equivalency factor for sections 4, B, and E.

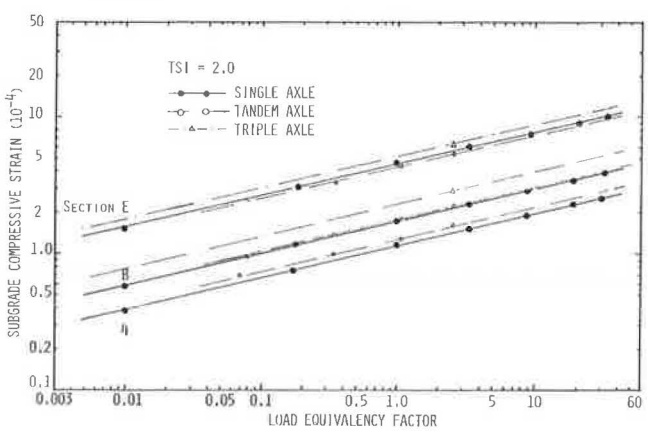
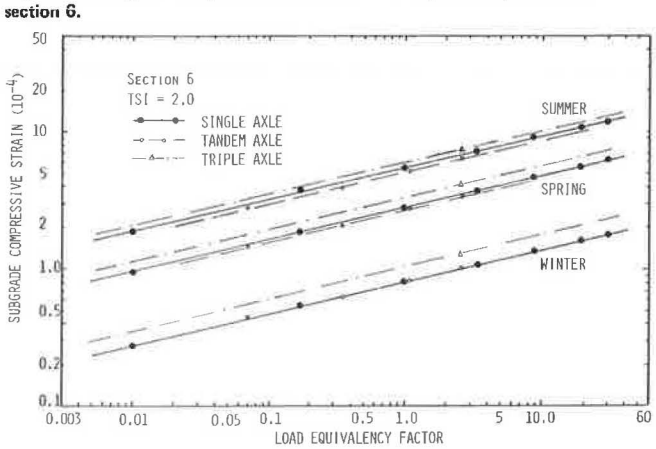


Figure 10. Subgrade compressive strain versus load equivalency factor for section 6.



SUMMARY AND CONCLUSIONS

The load equivalency factors of triaxle loading were evaluated by using both the AASHO empirical approach and the mechanistic approach. Specifically, the AASHO approach was adopted to determine the equivalency factors of 338-kN triaxle loading, and the mechanistic approach was used to include a broad range of triaxle load intensities.

To generate the required performance curves for the AASHO approach, the experimental pavements were subjected to approximately 55 000 repetitions of 338-kN triaxle loading. Based on the results obtained from the experimental pavements, the load equivalency factor of 338-kN triaxle loading was approximately 2.60 for the range of structural numbers investigated and for a terminal serviceability index of about 2.0.

For the mechanistic approach, the relations between load equivalency factors and the maximum vertical strain on the top of the subgrade were established for single- and tandem-axle loadings. These relations, in logarithmic coordinates, were straight lines parallel to each other. The load equivalency factor of 338-kip triaxle loading and its corresponding maximum subgrade strain were entered into the figure, and a straight line parallel to the lines for single- and tandem-axle loadings was drawn. The load equivalency factors of various triaxle loading intensities were then obtained by entering the maximum subgrade compressive strain of each loading intensity into the relation. The computed results are tabulated in Table 3.

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Table 3. Load equivalency factors and maximum vertical compressive strain on top of the subgrade.

	Section B, SN = 3.78		Section E, SN = 2.86		Section 4, SN = 5.26		Section 6, SN = 4.94			
Loading (kN)	E_f	$\epsilon_V(10^{-4})$	E_f	$\epsilon_V(10^{-4})$	E_f	$\epsilon_V(10^{-4})$	E_f	Spring	Summer	Winter
Single axle[a]										
27	0.01	0.592	0.01	1.57	0.01	0.392	0.01	0.956	1.89	0.275
53	0.18	1.18	0.19	3.13	0.17	0.784	0.17	1.90	3.75	0.548
80	1.00	1.76	1.00	4.63	1.00	1.17	1.00	2.83	5.44	0.817
107	3.35	2.35	3.45	6.18	3.43	1.55	3.40	3.76	7.38	1.09
133	8.77	2.93	9.32	7.68	8.84	1.94	8.72	4.69	9.18	1.36
160	19.33	3.50	21.37	9.12	19.25	2.32	19.01	5.59	10.9	1.62
178	31.61	3.88	34.71	10.1	30.34	2.58	30.03	6.21	12.1	1.80
Tandem axle										
80[a]	0.08	0.964	0.08	2.53	0.07	0.695	0.07	1.46	2.78	0.450
116[a]	0.35	1.39	0.36	3.36	0.35	0.998	0.35	2.10	3.96	0.630
151[a]	1.08	1.81	1.08	4.38	1.08	1.30	1.08	2.73	5.16	0.824
187[a]	2.62	2.24	2.65	5.39	2.64	1.61	2.64	3.38	6.36	1.02
222[b]	5.2	2.65	5.6	6.41	6.0	1.92	5.80	4.01	7.56	1.21
267[b]	11.1	3.18	12.0	7.65	12.6	2.30	12.60	4.80	9.02	1.45
Triple axle[b]										
67	0.0028	0.577	0.0025	1.30	0.0030	0.444	0.0026	0.833	1.53	0.258
111	0.024	0.962	0.022	2.16	0.024	0.739	0.024	1.38	2.52	0.430
156	0.101	1.35	0.10	3.02	0.11	1.04	0.10	1.93	3.52	0.601
200	0.30	1.73	0.29	3.86	0.30	1.33	0.29	2.48	4.49	0.771
245	0.70	2.11	0.67	4.69	0.70	1.62	0.70	3.18	5.45	0.939
289	1.44	2.50	1.30	5.56	1.40	1.92	1.40	3.57	6.47	1.11
334	2.50	2.87	2.50	6.39	2.50	2.22	2.50	4.10	7.43	1.28
338	2.60	2.91	2.60	6.45	2.60	2.25	2.60	4.15	7.53	1.30
378	4.30	3.25	4.20	7.20	4.60	2.51	4.40	4.64	8.37	1.44
423	7.00	3.63	6.60	8.03	6.70	2.80	7.00	5.18	9.33	1.61
467	10.4	4.01	10.0	8.82	11.0	3.09	10.7	5.70	10.2	1.78
512	15.0	4.38	15.0	9.63	16.5	3.39	16.0	6.23	11.2	1.96

Note: 1 kN = 0.225 kip.

[a]Load equivalency factors were obtained from AASHO road test.
[b]Load equivalency factors were from Figures 8 and 9, except for 338-kN (76-kip) triaxle loading, which was estimated by using the AASHO empirical approach.

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