Vehicle Weights and Dimensions Study

# Volume 9

## Pavement Response to Heavy Vehicle Test Program: Part 2 -- Load Equivalency Factors

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The Technical Steering Committee will be considering the findings of these research investigations in preparing its "Final Technical Report" (Volume 1 & 2), scheduled for completion in December 1986.

## PREFACE

The report which follows constitutes one volume in a series of sixteen which have been produced by contract researchers involved in the Vehicle Weights and Dimensions Study. The research procedures and findings contained herein address one or more specific technical objectives in the context of the development of a consistent knowledge base necessary to achieve the overall goal of the Study; improved uniformity in interprovincial weight and dimension regulations.

The Alberta Research Council was responsible for providing instrumentation and collecting pavement strain and deflection data at fourteen different test sites located across Canada. The cooperation and assistance of the following agencies and companies is gratefully acknowledged for their assistance in the conduct of this program:

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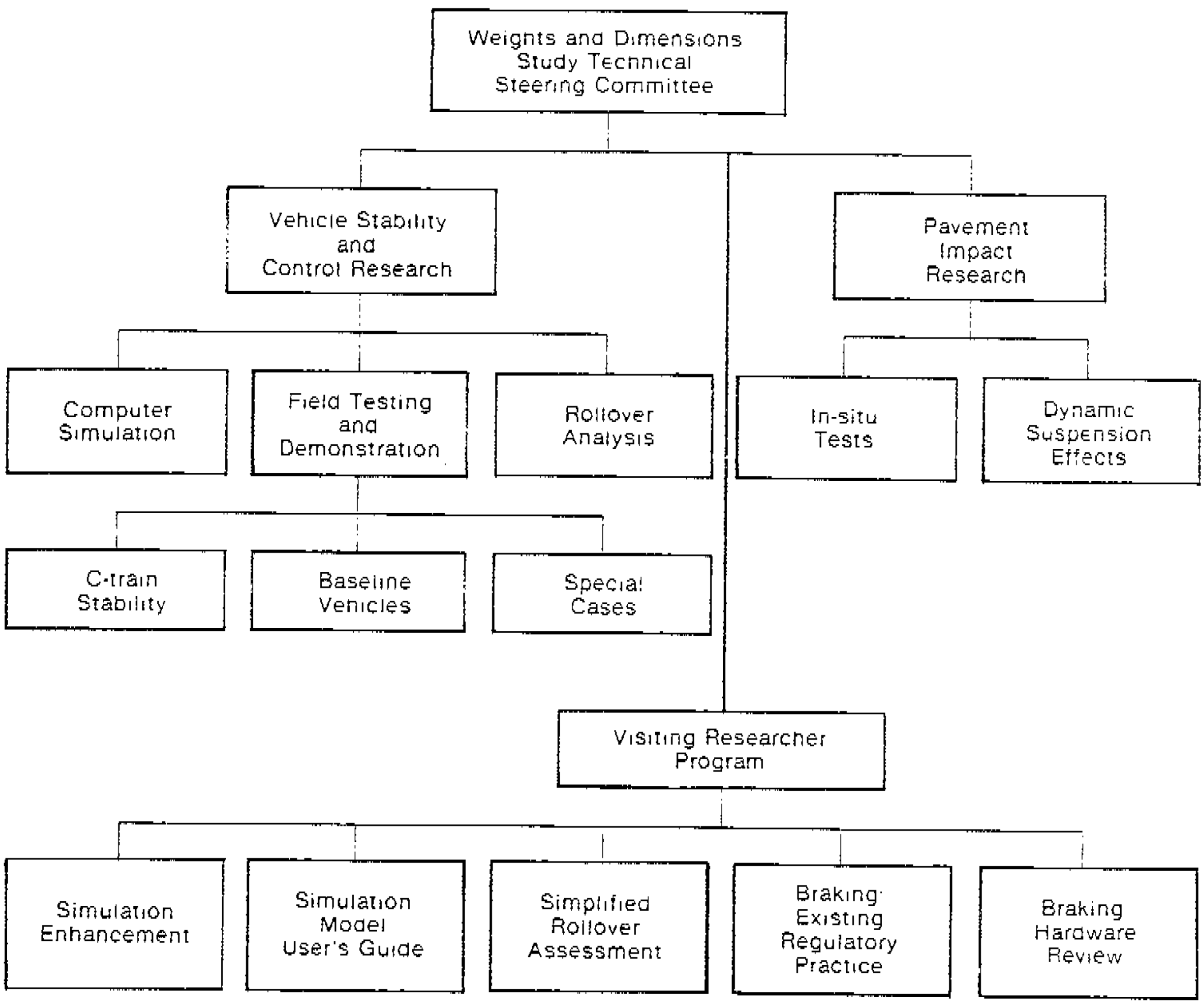
# HEAVY VEHICLE WEIGHTS AND DIMENSIONS STUDY

## TECHNICAL WORK ELEMENTS OVERVIEW



Volume 9

# Pavements Response to Heavy Vehicle Test Program: Part 2 — Load Equivalency Factors

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## 1.0 INTRODUCTION

During the summer of 1985, pavement surface deflections and interfacial tensile strains were recorded under a range of truck axle loads and configurations at fourteen instrumented pavement test sites located across Canada. The loading conditions included single, tandem and triaxle-dual tire configurations with gross weights ranging from approximately 9000 kg to 11 000 kg on single, 5500 kg to 22 000 kg on tandem, and from approximately 20 000 kg to 32 000 kg on triaxle configurations. Details of this extensive field testing program and summaries of the recorded pavement response variables are presented in the Pavement Impacts Investigation-Data Summary Report for this study. Using these field measurements and established pavement distress criteria, load equivalency factors for assessing the relative potential damaging effect of the traffic load variables on pavements have been developed.

This report describes the concepts used to develop the load equivalencies from the measured surface deflections and asphalt surface-base layer interfacial tensile strains. Data analysis procedures are described and predicted load equivalency factors for each test configuration are summarized by test site. From comparisons between the predicted factors, average loadings on different configurations equivalent in terms of potential damaging effect have been calculated and are presented with each test site summary. Analyses carried out to assess the influence of pavement structure on the magnitude of predicted load equivalency factors are described and results of the analyses are presented.

## 2.0 PAVEMENT RESPONSE - EQUIVALENCY FACTOR RELATIONSHIPS

Analysis of the destructive effects of traffic loadings on pavements is facilitated through use of load equivalency factors (F). These factors are defined as the number of applications ($N_b$) of a standard or base load which are equivalent in destructive effect to one application (N) of a given load; or $F = N_b/N$. Procedures used to predict load equivalency factors from in situ pavement surface deflections and interfacial tensile strain measurements are presented in Ref. 1. The following reviews the procedures as applied to the present study.

### 2.1 Deflection Response - Equivalency Relationships

The approach used to calculate equivalency factors from the pavement surface deflection measurements involved the use of limiting surface deflection - anticipated traffic loading relationships as shown in figure 2.1.

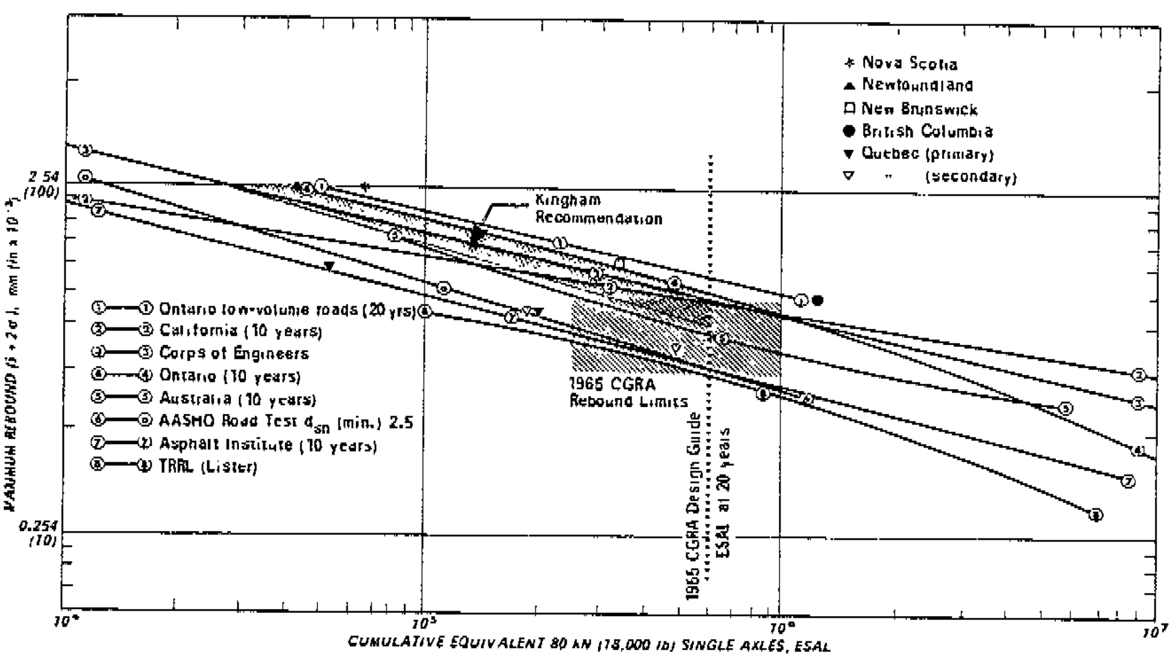


Figure 2.1 Maximum Benkelman Beam Rebound versus Cumulative Equivalent Single Axle Loads. (From Ref. 2)

These relationships indicate that pavement life, expressed in terms of equivalent standard load axle applications, $N_b$, can be approximated by the expression $N = K(1/D_b)^C$, where $D_b$ equals the magnitude of the pavement surface deflection under the standard single axle-dual tire load. Combining this expression with the definition of a load equivalency factor, equivalency factors for single axle loads were predicted using the expression:

$$F = (D/D_b)^C$$

where:

$D/D_b$ = the ratio of pavement surface deflections caused by a single axle load to those recorded under the standard 8160 kg single axle-dual tire load of the Benkelman Beam vehicle, and

$C$ = the slope of the deflection - anticipated traffic loading relationship.

A typical longitudinal surface deflection profile recorded under a triaxle configuration is shown in figure 2.2.

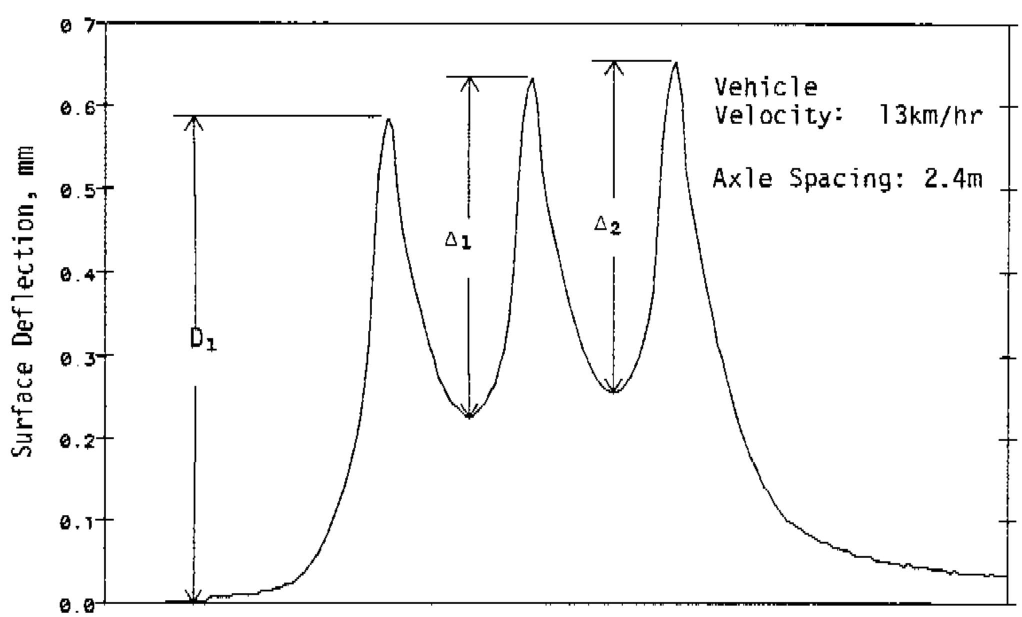


Figure 2.2 Surface Deflection Profile - Triaxle Configuration.

The general form of these profiles closely approximate longitudinal stress intensity profiles obtained from theoretical fracture mechanics concepts (Ref.3) and shown in figure 2.3. Suggested procedures for calculating equivalency factors from these profiles, shown on figure 2.3, were applied to the tandem and triaxle surface deflection records. Equivalency factors for these axle configurations were predicted using the expression:

$$F = (D_1/D_b)^C + \sum_{i=1}^{n-1} (\Delta i/D_b)^C$$

where:

$D_1/D_b$ = the ratio of maximum surface deflections under the leading axle of the axle group to those caused by the standard 8160 kg load,

$\Delta_i/D_b$ = the ratio of the difference in magnitude between the maximum deflection recorded under each succeeding axle and the minimum residual deflection preceding the axle ($\Delta$, refer to figure 2.2) to deflections caused by the standard load, and

n = the number of axles in the axle group.

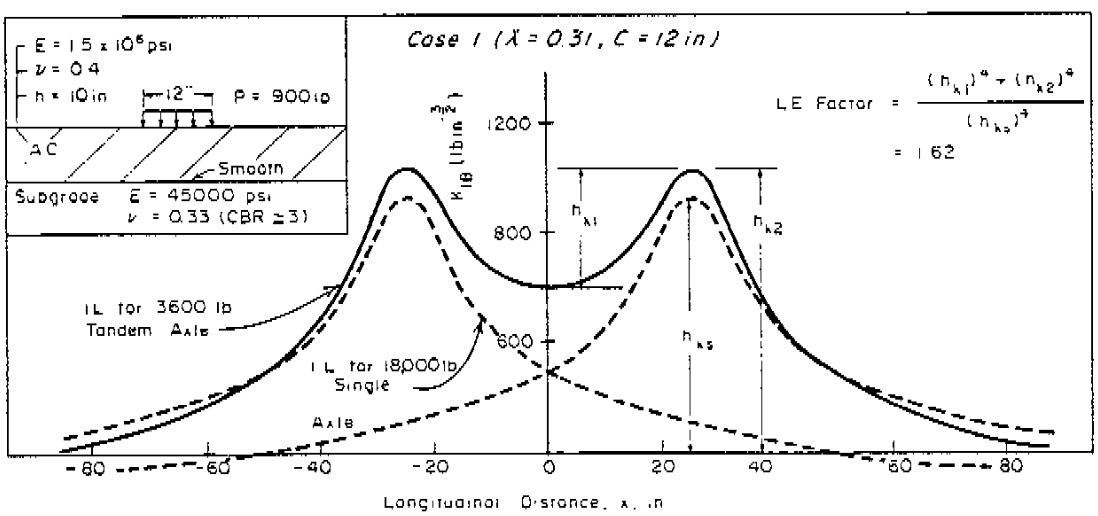


Figure 2.3 Load Equivalency Factor for Tandem Axle. (From Ref. 3)

## 2.2 Strain Response - Equivalency Relationship

A strain response profile at the asphalt concrete/base interface recorded under a triaxle load is shown in figure 2.4. Equivalency factor predictions from the tensile strain measurements involved the use of asphaltic concrete-fatigue life relationships as shown in figure 2.5. These relationships indicate that fatigue life, expressed in terms of the number of applications to failure, N, under a given load imposing a maximum tensile strain, S, can be approximated by the expression $N = K(1/S)^C$. Combining this expression with the definition of a load factor, equivalencies were predicted using the expression:

$$F = \sum_{i=1}^{n} (S_i/S_D)^C$$

where:

$S_i/S_D$ = the ratio of longitudinal interfacial tensile strains recorded under each axle to those recorded under the standard load,

n = the number of axles in the axle group, and

C = the slope of the fatique life-tensile strain relationship

Following the recommendations of the Pavements Advisory Committee to the study, average maximum deflection and strain values for each loading condition, tabulated in the Data Summary Report, were used for all load equivalency calculations. In addition, the exponents C were set equal to the recommended value of 3.8. This value is typical of results of laboratory fatigue tests on asphalt concrete mixes (figure 2.5) and approximates values ranging from 3.0 to 3.6 obtained from statistical correlations of deflection measurements with pavement serviceability levels (Ref.5) and obtained from pavement service life deflection studies (Ref.6).

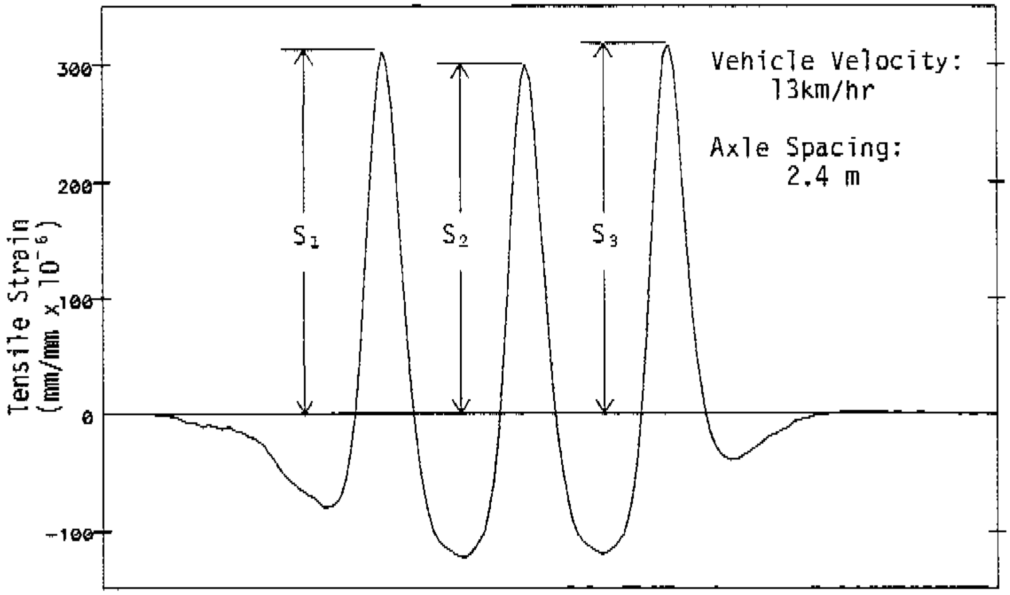


Figure 2.4 Longitudinal Interfacial Tensile Strain Profile-Triaxle Configuration.

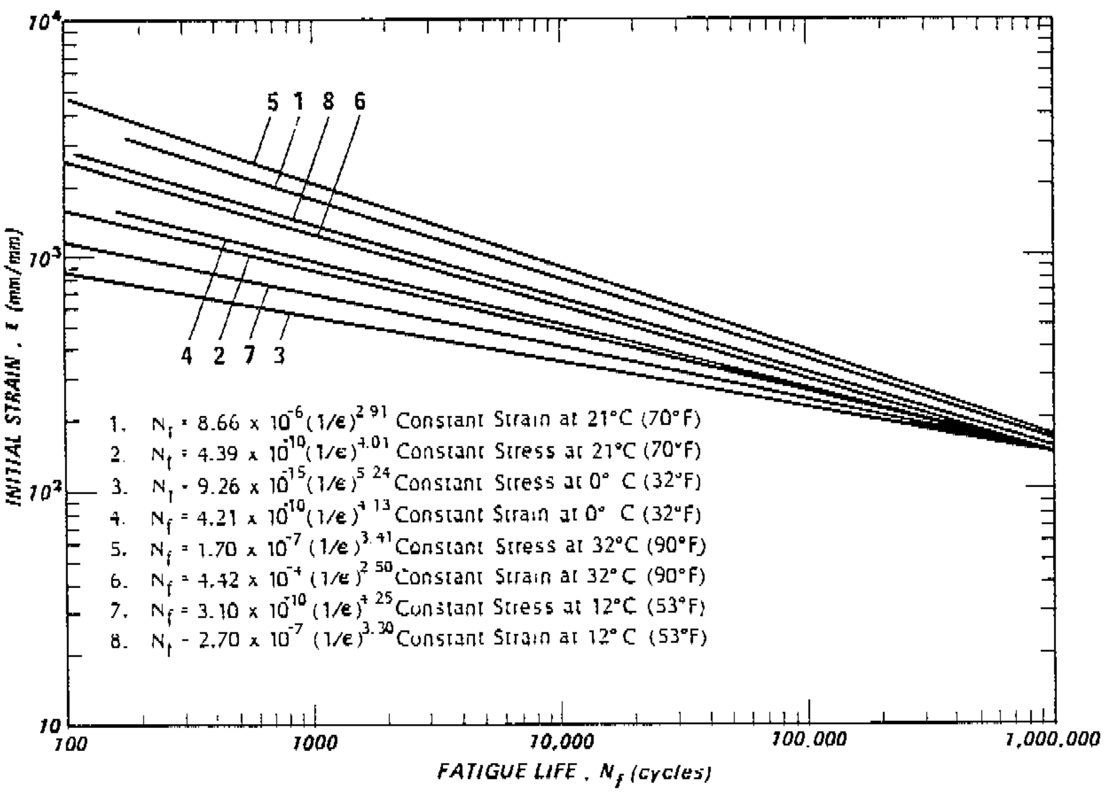


Figure 2.5 Fatigue Curves for Asphalt Concrete. (From Ref. 4)

## 3.0 DATA ANALYSIS

Average maximum pavement surface deflections and interfacial tensile strains for each loading condition were compared to those obtained from concurrent tests with the Benkelman Beam vehicle. These comparisons were in the form of deflection and strain ratios defined in Section 2. All loading conditions were tested at three vehicle velocities; approximately 6, 13 and 50 km/hr. The magnitude of the response ratios did not exhibit a consistent trend with velocity, remaining relatively constant over the three velocities for any given loading condition. (Maximum response ratios for a given load seldom exceeded minimum values by more than 10 percent). Therefore, the average of the three response ratios was used for the load equivalency predictions. An exception to this three point averaging was applied to strain measurements at site 12 - British Columbia. Strain ratios for the 50 km/hr test series at this site showed a wide variation in magnitude with little correlation with load. Reasons for this response are unknown. Load equivalencies based on strains at site 12 were predicted using the average response ratios for the two lower velocities.

Plots of axle weight versus deflection and strain ratios and summaries of regression analyses for tandem and triaxle configurations are presented in the Appendix. The figures reveal some data irregularities and show the influence of axle spacing on the magnitude of the pavement response ratios. These observations are discussed below.

### 3.1 Deflection Response

With the exception of site 2 - Nova Scotia and site 12 - British Columbia, deflections were highly correlated with axle load. At site 2, relatively large residual deflections were recorded between the tandem drive axles and the carrying axles of the pavement test vehicle. These residual deflections ranged from approximately 0.05 mm to 0.20 mm, with maximum values generally associated with tests conducted at high pavement temperatures (35C). Equivalency factors for carrying axle loads tested at site 2 were calculated using deflections equal to the difference in magnitude between maximum deflections recorded under the axles and the residual deflections. Relative deflection values for site 12 - British Columbia, shown in figure A24, exhibited unusually wide variations in magnitude with changes in axle load. A detailed re-examination of the deflection measurements verified this behaviour.

The axle weight versus deflection ratio plots reveal that, at comparable loads, a variation in centre to centre spacing between adjacent axles from 1.5 m to 1.8 m had little, if any, influence on maximum surface deflections. Maximum deflections under adjacent axles at 1.2 m spacings were generally slightly larger in magnitude than those under axles with 1.5 m and 1.8 m spacings.

### 3.2 Strain Response

The axle weight versus strain ratio plots indicate that, at a number of sites, longitudinal interfacial tensile strains were relatively insensitive to changes in axle weight. At some sites, strain ratios for a given test configuration decreased with increasing load. Sites where one or more carrying axle test configurations revealed a decrease in relative strain values with increasing load were sites 4 and 5 in Quebec, site 6 - Ontario and site 12 - British Columbia. The relatively thin asphalt surfaces (ranging from 56 mm to 110 mm) of these pavement structures, high pavement temperatures (35C to 40C) during testing, and any small lateral misalignment of buried strain transducers relative to surface-set deflection transducer locations under these test conditions, may be contributing factors to these inconsistent measurements. In addition, plywood shipping stiffeners for the strain transducers were left in place during paving operations at sites 3A and 3B in Quebec. Therefore, strain recorded at these two sites should not be representative of the pavement response to load.

Equivalency factors based on strains were predicted for all loading conditions tested at each site. In view of the above noted irregularities, strain-related equivalencies for some configurations tested at the previously mentioned sites should be viewed with caution. Due to a computer hardware malfunction, strains were not recorded at site 11 - British Columbia. The axle weight versus strain ratio plots reveal that a variation in spacing between adjacent axles from 1.2 m to 1.8 m had no measurable influence on the magnitude of interfacial tensile strains recorded under the lead axle of tandem and triaxle configurations.

### 3.3 Equivalent Loadings

Detail assessments of the relative destructive effects of traffic load variables on pavements involve identifying loads on different configurations which are equivalent in potential damaging effect. Such assessments can readily be carried out if gross weight versus load equivalency factor relationships are established for each axle configuration and the relationships encompass a common range of equivalency factor values. In the present study, a maximum of three loads/carrying axle configuration of the test vehicle were tested at each site. This did not provide sufficient data to develop reliable carrying axle gross weight-equivalency factor relationships.

In view of the above data limitations, deflections and strains recorded under the tandem (1.5 m) drive axles of the test vehicle were included in the analysis. At comparable load magnitudes, deflection and strain ratios, and therefore load equivalency factors, for the tandem drive axles were found to be in close agreement with those for the tandem (1.8 m) carrying axle configuration. Combining the data populations of these two axle groupings, gross weight versus load equivalency factor relationships for tandem (1.5 m to 1.8 m) axle-dual tire loads ranging from 5445 to 22 100 kg have been developed for each site. Using these relationships, tandem axle gross weights yielding equivalency factors equal in magnitude to those predicted for all other carrying axle loads and configurations have been identified.

## 4.0 LOAD EQUIVALENCY FACTORS

The following presents the predicted load equivalency factors, and, using these factors, summarizes results of analyses carried out to identify average loadings on different configurations which are equivalent in potential damaging effect. The predicted factors and analysis summaries are presented by test site in a common format as follows:

1. a table containing the average pavement surface deflection ratios, the average interfacial tensile strain ratios, and load equivalency factors derived from these ratios for each loading condition tested at the site, (The pavement response ratios are defined in Sections 2.1 and 2.2 of this report. The average values equal the mean of response ratios determined from test series carried out at three vehicle velocity levels; approximately 6, 13 and 50 km/hr.)

2. gross weight versus load equivalency factor plots for each test configuration,

3. results of least-squares regression analyses carried out to develop gross weight versus equivalency factor relationships for tandem (1.5 m to 1.8 m) axle-dual tire configurations, and

4. average gross weights on each configuration equivalent in potential damaging effect to tandem (1.5 m to 1.8 m) axle loads. The average equivalent gross weights are expressed as a percent of the tandem axle loads.

Utilizing the results obtained from all test sites, average tandem (1.5 m to 1.8 m) axle loads equivalent in damaging effect to all other carrying axle loading conditions included in the study, and the relative destructive effects of each configuration at comparable load magnitudes, are summarized in Section 4.15.

## 4.1 LOAD EQUIVALENCY FACTORS

SITE 1

NEW BRUNSWICK

**Table 4.1**
**Average Pavement Response Ratios and Load Equivalency Factors, Site 1, New Brunswick**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Steering Axle | | | | | | | | |
| 3790 kg | 0.589 | | | 0.664 | | | 0.134 | 0.211 |
| 5110 kg | 0.762 | | | 0.826 | | | 0.356 | 0.484 |
| Single Axle | | | | | | | | |
| 9182 kg | 1.201 | | | 1.153 | | | 2.006 | 1.718 |
| 9570 kg | 1.255 | | | 1.183 | | | 2.371 | 1.894 |
| 11127 kg | 1.315 | | | 1.237 | | | 2.831 | 2.244 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.003 | 0.681 | | 0.813 | 0.784 | | 1.244 | 0.852 |
| 18100 kg | 1.233 | 0.703 | | 1.077 | 0.969 | | 2.479 | 2.213 |
| 22327 kg | 1.384 | 0.811 | | 1.191 | 1.145 | | 3.889 | 3.398 |
| Tandem axle (1.5m) | | | | | | | | |
| 5445 kg | 0.577 | 0.477 | | 0.342 | 0.330 | | 0.184 | 0.032 |
| 6682 kg | 0.678 | 0.501 | | 0.450 | 0.424 | | 0.301 | 0.086 |
| 8209 kg | 0.738 | 0.583 | | 0.536 | 0.537 | | 0.444 | 0.188 |
| 9109 kg | 0.824 | 0.681 | | 0.647 | 0.731 | | 0.711 | 0.495 |
| 9565 kg | 0.786 | 0.678 | | 0.644 | 0.642 | | 0.629 | 0.373 |
| 10345 kg | 0.803 | 0.693 | | 0.718 | 0.708 | | 0.683 | 0.553 |
| 10645 kg | 0.793 | 0.624 | | 0.740 | 0.727 | | 0.581 | 0.616 |
| 11718 kg | 0.944 | 0.726 | | 0.753 | 0.740 | | 1.100 | 0.659 |
| 11827 kg | 0.938 | 0.715 | | 0.727 | 0.729 | | 1.064 | 0.699 |
| 12500 kg | 0.942 | 0.764 | | 0.828 | 0.850 | | 1.156 | 1.027 |
| 13136 kg | 0.975 | 0.793 | | 0.868 | 0.844 | | 1.323 | 1.084 |
| 13236 kg | 1.000 | 0.675 | | 0.829 | 0.807 | | 1.225 | 0.933 |
| 14582 kg | 1.002 | 0.848 | | 0.902 | 0.903 | | 1.542 | 1.354 |
| 14936 kg | 1.039 | 0.791 | | 0.946 | 0.934 | | 1.567 | 1.581 |
| 15336 kg | 0.982 | 0.780 | | 0.906 | 0.891 | | 1.322 | 1.332 |
| 15582 kg | 1.074 | 0.883 | | 0.967 | 0.963 | | 1.935 | 1.747 |
| 19280 kg | 1.346 | 0.874 | | 1.171 | 1.150 | | 3.692 | 3.523 |
| Tandem axle (1.8m) | | | | | | | | |
| 14064 kg | 0.900 | 0.825 | | 0.849 | 0.917 | | 1.151 | 1.256 |
| 18382 kg | 1.141 | 0.980 | | 1.002 | 1.074 | | 2.577 | 2.319 |
| 22127 kg | 1.394 | 1.108 | | 1.306 | 1.327 | | 5.010 | 5.688 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 0.994 | 0.631 | 0.654 | 0.813 | 0.726 | 0.802 | 1.350 | 1.184 |
| 26145 kg | 1.121 | 0.707 | 0.710 | 0.995 | 0.909 | 0.986 | 2.083 | 2.625 |
| 31645 kg | 1.325 | 0.787 | 0.759 | 1.153 | 1.058 | 1.146 | 3.667 | 4.635 |
| Triaxle (3.7) | | | | | | | | |
| 20510 kg | 0.917 | 0.856 | 0.833 | 0.764 | 0.828 | 0.900 | 1.773 | 1.518 |
| 26036 kg | 1.101 | 0.980 | 0.932 | 0.941 | 1.005 | 1.091 | 3.133 | 3.206 |
| 31664 kg | 1.190 | 1.096 | 1.038 | 1.058 | 1.143 | 1.253 | 4.506 | 5.257 |
| Triaxle (4.9) | | | | | | | | |
| 25856 kg | 1.075 | 1.079 | 0.955 | 0.968 | 1.009 | 1.078 | 3.491 | 3.249 |
| 31955 kg | 1.223 | 1.233 | 1.146 | 1.143 | 1.221 | 1.343 | 6.044 | 6.864 |

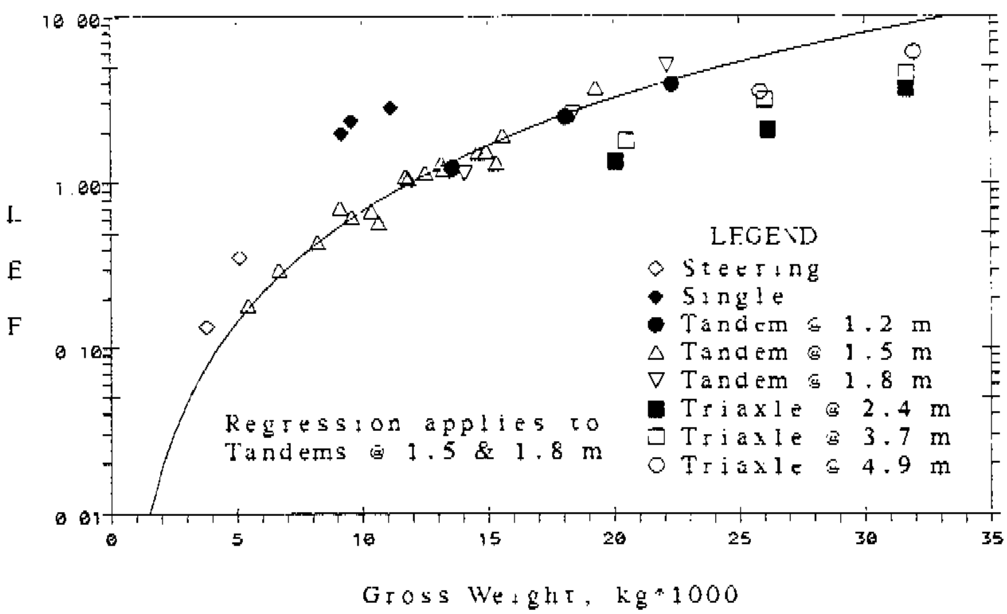


Figure 4.1: Load Equivalency Factors based on Deflections: Site 1, New Brunswick

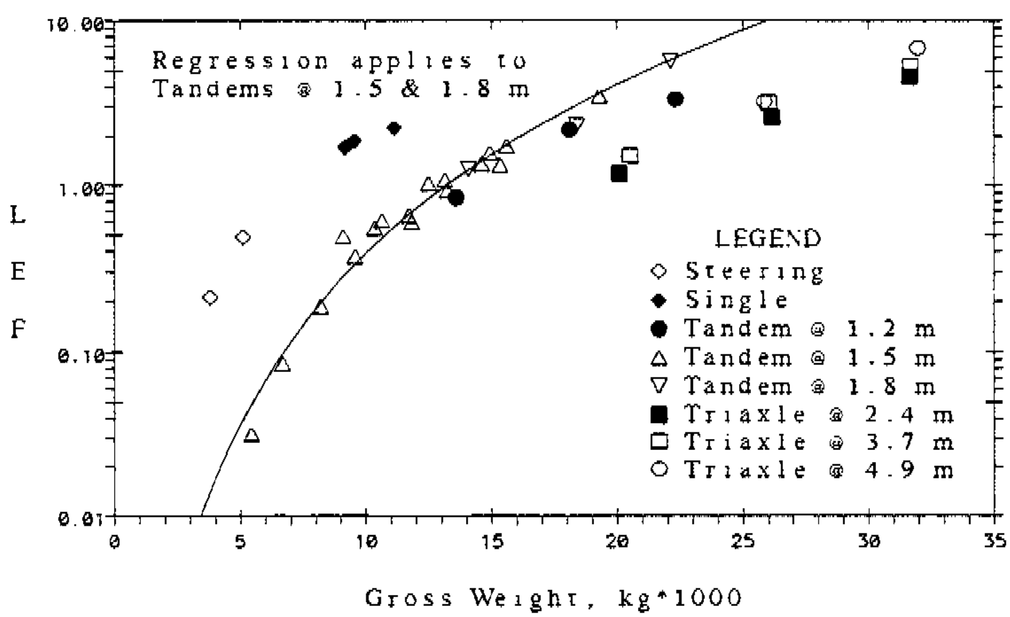


Figure 4.2: Load Equivalency Factors based on Strains: Site 1, New Brunswick

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.0040\ (GW)^{2.230}\quad r^2 = 0.90\quad N = 20\quad \ell S_{ey} = 0.066$

Based on Strains:

$F = 0.000153\ (GW)^{3.405}\quad r^2 = 0.97\quad N = 20\quad \ell S_{ey} = 0.093$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights and load applications are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of an 11900 kg (13200 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 57 (62) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 102 (110) |
| Triaxle (2.4 m) | 151 (148) |
| Triaxle (3.7 m) | 133 (142) |
| Triaxle (4.9 m) | 122 (138) |

3. At comparable load magnitudes (approximately 5000 kg), one application of a single steering axle is equivalent in potential damaging effect to approximately 3 (15) applications of tandem axle (1.5 -1.8 m) - dual tire configuration.

## 4.2 LOAD EQUIVALENCY FACTORS

SITE 2

NOVA SCOTIA

**Table 4.2**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 2, Nova Scotia**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| **Steering Axle** | | | | | | | | |
| 3790 kg | 0.743 | | | 0.766 | | | 0.323 | 0.363 |
| 5110 kg | 0.955 | | | 0.928 | | | 0.839 | 0.753 |
| **Single Axle** | | | | | | | | |
| 9182 kg | 1.001 | | | 0.998 | | | 1.004 | 0.992 |
| 11127 kg | 1.124 | | | 1.043 | | | 1.559 | 1.173 |
| **Tandem Axle (1.2m)** | | | | | | | | |
| 13582 kg | 0.968 | 0.674 | | 0.870 | 0.813 | | 1.107 | 1.044 |
| 18100 kg | 1.058 | 0.626 | | 0.947 | 0.935 | | 1.406 | 1.568 |
| 22327 kg | 1.250 | 0.830 | | 1.025 | 0.956 | | 2.827 | 1.941 |
| **Tandem Axle (1.5m)** | | | | | | | | |
| 5445 kg | 0.549 | 0.403 | | 0.476 | 0.436 | | 0.134 | 0.102 |
| 9109 kg | 0.695 | 0.487 | | 0.632 | 0.621 | | 0.316 | 0.338 |
| 9555 kg | 0.792 | 0.593 | | 0.719 | 0.670 | | 0.550 | 0.504 |
| 10345 kg | 0.815 | 0.616 | | 0.806 | 0.751 | | 0.618 | 0.777 |
| 10645 kg | 0.864 | 0.612 | | 0.836 | 0.786 | | 0.729 | 0.907 |
| 11718 kg | 0.804 | 0.550 | | 0.768 | 0.747 | | 0.540 | 0.697 |
| 11817 kg | 0.843 | 0.612 | | 0.786 | 0.763 | | 0.677 | 0.758 |
| 12500 kg | 1.037 | 0.776 | | 0.847 | 0.790 | | 1.530 | 0.940 |
| 13136 kg | 1.115 | 0.774 | | 0.888 | 0.825 | | 1.890 | 1.118 |
| 13236 kg | 0.926 | 0.623 | | 0.831 | 0.815 | | 0.912 | 0.954 |
| 14582 kg | 1.074 | 0.779 | | 0.899 | 0.835 | | 1.699 | 1.171 |
| 14936 kg | 0.998 | 0.704 | | 0.903 | 0.872 | | 1.256 | 1.273 |
| 15336 kg | 1.133 | 0.788 | | 0.904 | 0.846 | | 2.012 | 1.211 |
| 15582 kg | 1.161 | 0.852 | | 0.931 | 0.884 | | 2.308 | 1.388 |
| **Tandem Axle (1.8m)** | | | | | | | | |
| 14064 kg | 0.948 | 0.852 | | 0.897 | 0.884 | | 1.360 | 1.288 |
| 18382 kg | 1.000 | 0.860 | | 0.956 | 0.980 | | 1.564 | 1.769 |
| 22127 kg | 1.103 | 0.922 | | 1.048 | 1.073 | | 2.502 | 2.502 |
| **Triaxle (2.4m)** | | | | | | | | |
| 20082 kg | 1.002 | 0.714 | 0.665 | 0.873 | 0.798 | 0.789 | 1.498 | 1.427 |
| 26145 kg | 1.019 | 0.670 | 0.638 | 0.931 | 0.860 | 0.886 | 1.474 | 1.957 |
| 31645 kg | 1.151 | 0.722 | 0.663 | 1.011 | 0.947 | 0.973 | 2.206 | 2.757 |
| **Triaxle (3.7m)** | | | | | | | | |
| 20509 kg | 0.819 | 0.763 | 0.769 | 0.786 | 0.817 | 0.825 | 1.195 | 1.346 |
| 26036 kg | 0.880 | 0.799 | 0.821 | 0.867 | 0.913 | 0.962 | 1.514 | 2.152 |
| 31664 kg | 1.027 | 0.939 | 0.944 | 0.948 | 0.944 | 0.931 | 2.697 | 2.382 |

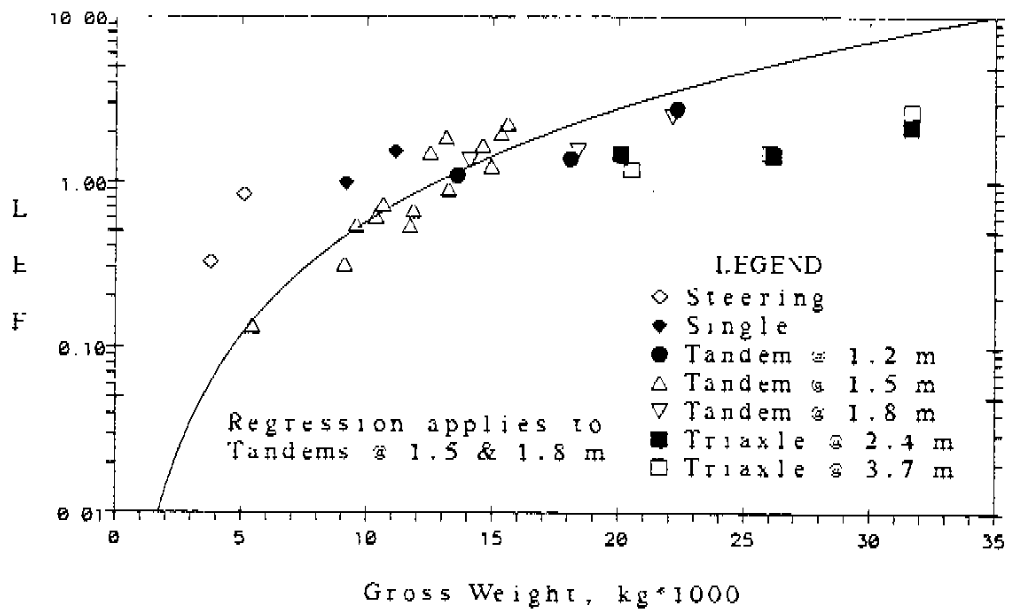


Figure 4.3: Load Equivalency Factors based on Deflections: Site 2, Nova Scotia

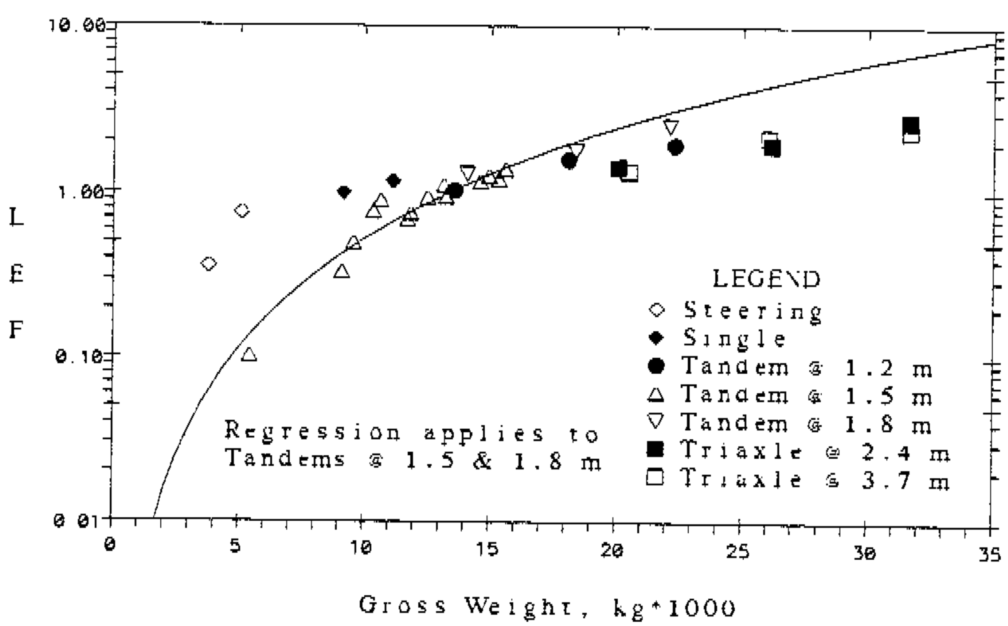


Figure 4.4: Load Equivalency Factors based on Strains: Site 2, Nova Scotia

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.0029\ (GW)^{2.296}\quad r^2 = 0.84\quad N = 17\quad \ell S_{ey} = 0.134$

Based on Strains:

$F = 0.00318\ (GW)^{2.219}\quad r^2 = 0.94\quad N = 17\quad \ell S_{ey} = 0.080$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights and load applications are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12700 kg (13400 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 72 (73) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 112 (111) |
| Triaxle (2.4 m) | 157 (141) |
| Triaxle (3.7 m) | 160 (144) |

3. At comparable load magnitudes (approximately 5000 kg), one application of a single steering axle is equivalent in potential damaging effect to approximately 7 (8) applications of tandem axle (1.5 -1.8 m) - dual tire configuration.

## 4.3 LOAD EQUIVALENCY FACTORS

SITE 3A

QUEBEC

**Table 4.3**
**Average Pavement Response Ratios and Load Equivalency Factors, Site 3A, Quebec**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Single Axle | | | | | | | | |
| 9182 kg | 1.196 | | | 1.024 | | | 1.974 | 1.094 |
| 9570 kg | 1.193 | | | 1.115 | | | 1.955 | 1.512 |
| 11127 kg | 1.306 | | | 1.247 | | | 2.758 | 2.314 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.029 | 0.660 | | 0.848 | 0.807 | | 1.321 | 0.977 |
| 18100 kg | 1.315 | 0.794 | | 0.936 | 0.959 | | 3.247 | 1.631 |
| 22327 kg | 1.359 | 0.808 | | 1.064 | 1.001 | | 3.653 | 2.270 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.523 | 0.415 | | 0.355 | 0.356 | | 0.121 | 0.039 |
| 6682 kg | 0.670 | 0.494 | | 0.433 | 0.433 | | 0.287 | 0.083 |
| 8209 kg | 0.756 | 0.599 | | 0.606 | 0.598 | | 0.488 | 0.291 |
| 9109 kg | 0.806 | 0.614 | | 0.555 | 0.547 | | 0.595 | 0.208 |
| 9556 kg | 0.804 | 0.629 | | 0.656 | 0.641 | | 0.608 | 0.386 |
| 10345 kg | 0.860 | 0.673 | | 0.620 | 0.599 | | 0.786 | 0.306 |
| 10645 kg | 0.909 | 0.700 | | 0.618 | 0.639 | | 0.954 | 0.343 |
| 11718 kg | 0.945 | 0.709 | | 0.708 | 0.697 | | 1.077 | 0.523 |
| 11827 kg | 0.920 | 0.715 | | 0.602 | 0.593 | | 1.008 | 0.283 |
| 12500 kg | 0.932 | 0.718 | | 0.663 | 0.718 | | 1.049 | 0.494 |
| 13136 kg | 0.965 | 0.741 | | 0.755 | 0.814 | | 1.193 | 0.801 |
| 13236 kg | 1.041 | 0.808 | | 0.734 | 0.758 | | 1.610 | 0.658 |
| 14582 kg | 1.043 | 0.818 | | 0.834 | 0.819 | | 1.640 | 0.970 |
| 14936 kg | 1.117 | 0.846 | | 0.731 | 0.747 | | 2.052 | 0.634 |
| 15336 kg | 1.016 | 0.780 | | 0.801 | 0.763 | | 1.451 | 0.825 |
| 15582 kg | 1.133 | 0.788 | | 0.778 | 0.776 | | 2.012 | 0.767 |
| 19280 kg | 1.235 | 0.868 | | 1.027 | 0.974 | | 2.814 | 2.011 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.003 | 0.804 | | 0.737 | 0.793 | | 1.448 | 0.728 |
| 18382 kg | 1.241 | 0.973 | | 0.921 | 0.936 | | 3.173 | 1.509 |
| 22127 kg | 1.358 | 1.034 | | 1.094 | 1.017 | | 4.335 | 2.473 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.051 | 0.601 | 0.617 | 0.727 | 0.692 | 0.709 | 1.152 | 0.815 |
| 26145 kg | 1.156 | 0.780 | 0.748 | 0.960 | 0.927 | 0.890 | 2.456 | 2.248 |
| 31645 kg | 1.420 | 0.860 | 0.848 | 1.063 | 0.974 | 0.993 | 4.864 | 3.140 |
| Triaxle (3.7m) | | | | | | | | |
| 20609 kg | 0.995 | 0.806 | 0.786 | 0.774 | 0.843 | 0.858 | 1.822 | 1.469 |
| 26036 kg | 1.143 | 0.892 | 0.927 | 0.824 | 0.915 | 0.925 | 3.059 | 1.936 |
| 31664 kg | 1.280 | 1.030 | 1.033 | 0.920 | 1.028 | 1.074 | 4.805 | 3.151 |
| Triaxle (4.9m) | | | | | | | | |
| 25836 kg | 1.134 | 1.032 | 0.942 | 0.882 | 0.989 | 0.939 | 3.537 | 2.367 |
| 31955 kg | 1.354 | 1.263 | 1.111 | 0.883 | 0.973 | 0.962 | 7.084 | 2.388 |

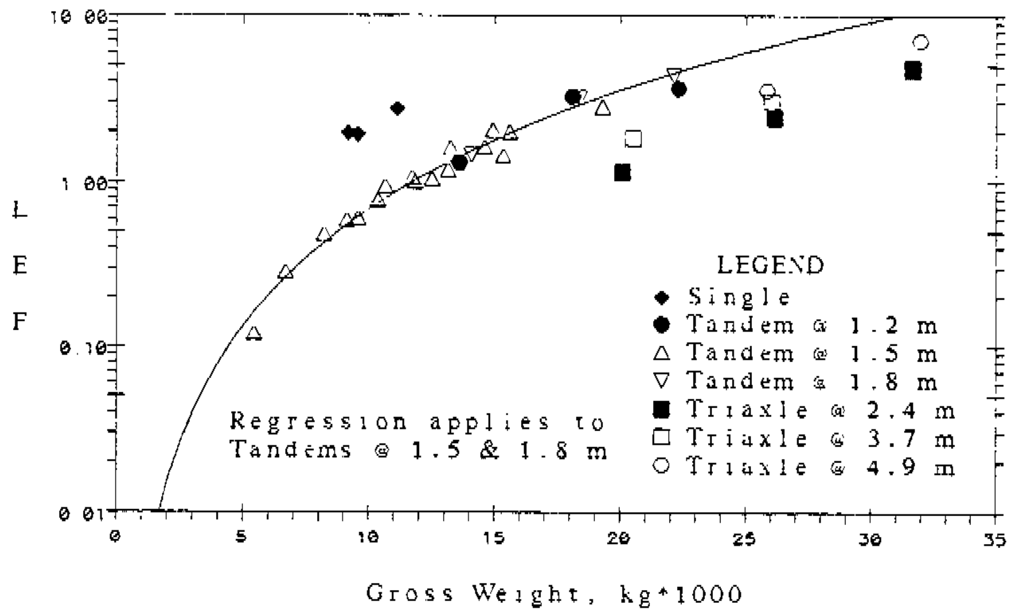


Figure 4.5: Load Equivalency Factors based on Deflections: Site 3A, Quebec

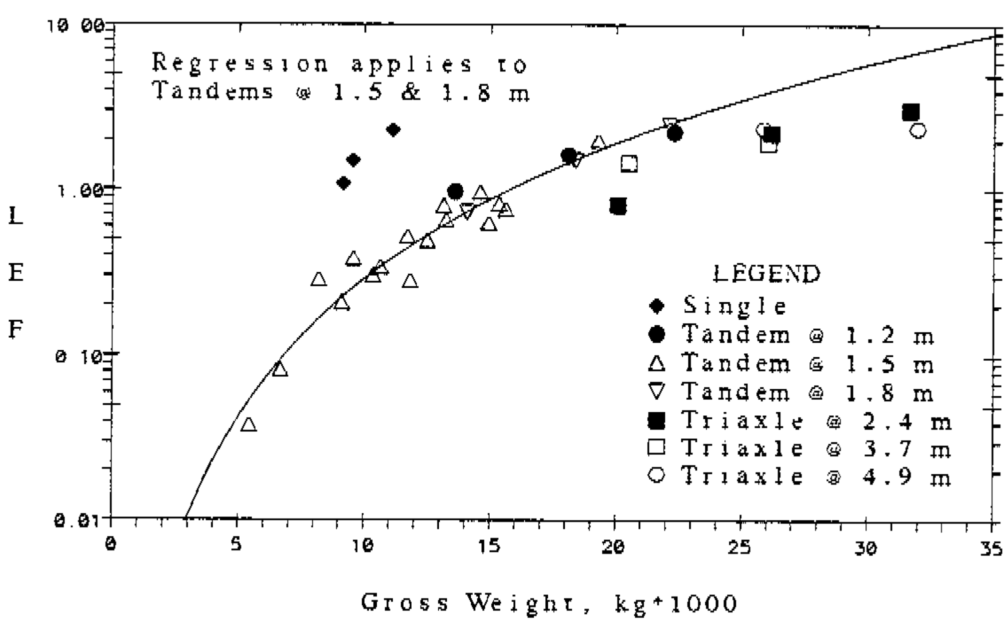


Figure 4.6: Load Equivalency Factors based on Strains: Site 3A, Quebec

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.00294\ (GW)^{2.368}$ $r^2 = 0.97$ $N = 20$ $\ell S_{ey} = 0.058$

Based on Strains:

$F = 0.000512\ (GW)^{2.748}$ $r^2 = 0.97$ $N = 20$ $\ell S_{ey} = 0.108$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of an 11700 kg (15800 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 60 (53) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 102 ( 96) |
| Triaxle (2.4 m) | 151 (131) |
| Triaxle (3.7 m) | 138 (125) |
| Triaxle (4.9 m) | 124 (134) |

## 4.4 LOAD EQUIVALENCY FACTORS

SITE 3B

QUEBEC

**Table 4.4**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 3B, Quebec**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections | | | Interfacial Tensile Strains | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Single axle | | | | | | | | |
| 9182 kg | 1.187 | | | 1.084 | | | 1.918 | 1.359 |
| 9570 kg | 1.256 | | | 1.089 | | | 2.378 | 1.383 |
| 11127 kg | 1.335 | | | 1.206 | | | 2.998 | 2.038 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.089 | 0.695 | | 0.996 | 0.939 | | 1.634 | 1.772 |
| 18100 kg | 1.231 | 0.765 | | 1.079 | 1.093 | | 2.564 | 2.737 |
| 22327 kg | 1.404 | 0.791 | | 1.140 | 1.079 | | 4.041 | 2.980 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.514 | 0.368 | | 0.565 | 0.547 | | 0.100 | 0.215 |
| 6682 kg | 0.661 | 0.475 | | 0.759 | 0.746 | | 0.266 | 0.679 |
| 8209 kg | 0.756 | 0.591 | | 0.877 | 0.857 | | 0.481 | 1.164 |
| 9109 kg | 0.773 | 0.581 | | 0.801 | 0.817 | | 0.503 | 0.894 |
| 9555 kg | 0.798 | 0.671 | | 0.912 | 0.860 | | 0.644 | 1.268 |
| 10345 kg | 0.823 | 0.623 | | 0.775 | 0.776 | | 0.643 | 0.761 |
| 10645 kg | 0.843 | 0.603 | | 0.837 | 0.848 | | 0.669 | 1.043 |
| 11718 kg | 0.920 | 0.734 | | 0.907 | 0.931 | | 1.037 | 1.452 |
| 11827 kg | 0.868 | 0.738 | | 0.896 | 0.921 | | 0.899 | 1.390 |
| 12500 kg | 0.913 | 0.761 | | 0.885 | 0.949 | | 1.062 | 1.448 |
| 13136 kg | 0.971 | 0.774 | | 0.948 | 0.992 | | 1.272 | 1.786 |
| 13236 kg | 1.019 | 0.799 | | 1.001 | 1.004 | | 1.500 | 2.019 |
| 14582 kg | 1.017 | 0.813 | | 1.014 | 1.008 | | 1.522 | 2.085 |
| 14936 kg | 1.030 | 0.845 | | 0.955 | 0.996 | | 1.646 | 1.824 |
| 15336 kg | 1.031 | 0.761 | | 0.972 | 0.961 | | 1.477 | 1.757 |
| 15582 kg | 1.079 | 0.784 | | 1.001 | 1.022 | | 1.732 | 2.090 |
| 19280 kg | 1.241 | 0.921 | | 1.120 | 1.116 | | 3.003 | 3.056 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.009 | 0.827 | | 0.959 | 0.968 | | 1.521 | 1.737 |
| 18382 kg | 1.195 | 0.990 | | 1.076 | 1.082 | | 2.930 | 2.670 |
| 22127 kg | 1.337 | 1.049 | | 1.141 | 1.111 | | 4.214 | 3.143 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.029 | 0.590 | 0.564 | 0.992 | 0.965 | 0.956 | 1.363 | 2.686 |
| 26145 kg | 1.263 | 0.774 | 0.719 | 1.091 | 1.017 | 0.988 | 3.092 | 3.414 |
| 31645 kg | 1.330 | 0.785 | 0.738 | 1.116 | 1.088 | 1.057 | 3.669 | 4.130 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 0.998 | 0.849 | 0.875 | 0.965 | 0.954 | 0.966 | 2.131 | 2.586 |
| 26036 kg | 1.127 | 0.929 | 0.922 | 1.024 | 1.049 | 1.080 | 3.065 | 3.633 |
| 31664 kg | 1.232 | 0.956 | 0.936 | 1.054 | 1.095 | 1.101 | 3.830 | 4.074 |
| Triaxle (4.9m) | | | | | | | | |
| 25836 kg | 1.142 | 1.002 | 0.928 | 1.072 | 1.054 | 1.037 | 3.417 | 3.672 |
| 31995 kg | 1.290 | 1.151 | 0.994 | 1.096 | 1.105 | 1.054 | 5.316 | 4.099 |

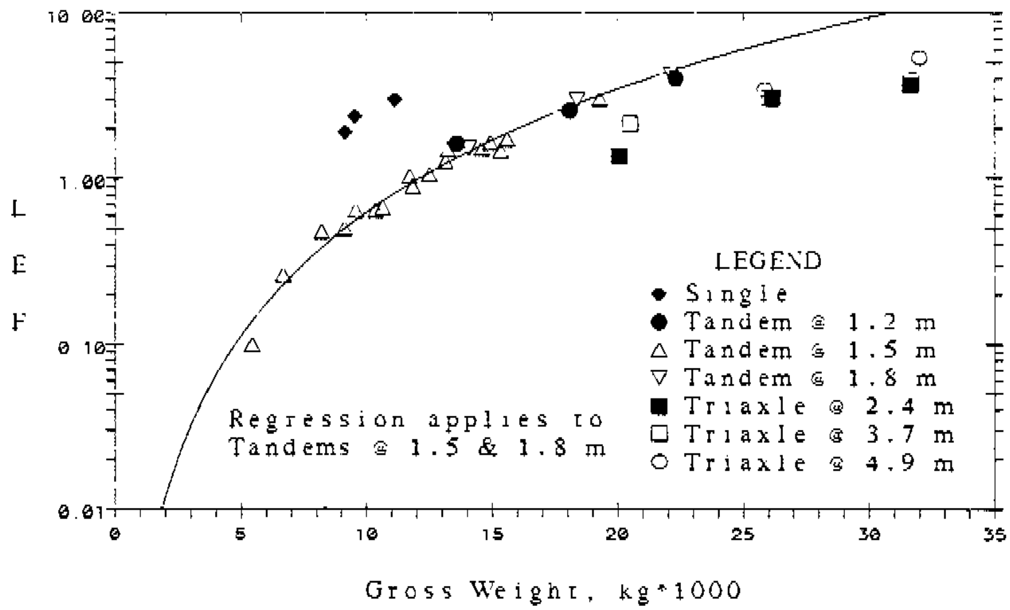


Figure 4.7: Load Equivalency Factors based on Deflections: Site 3B, Quebec

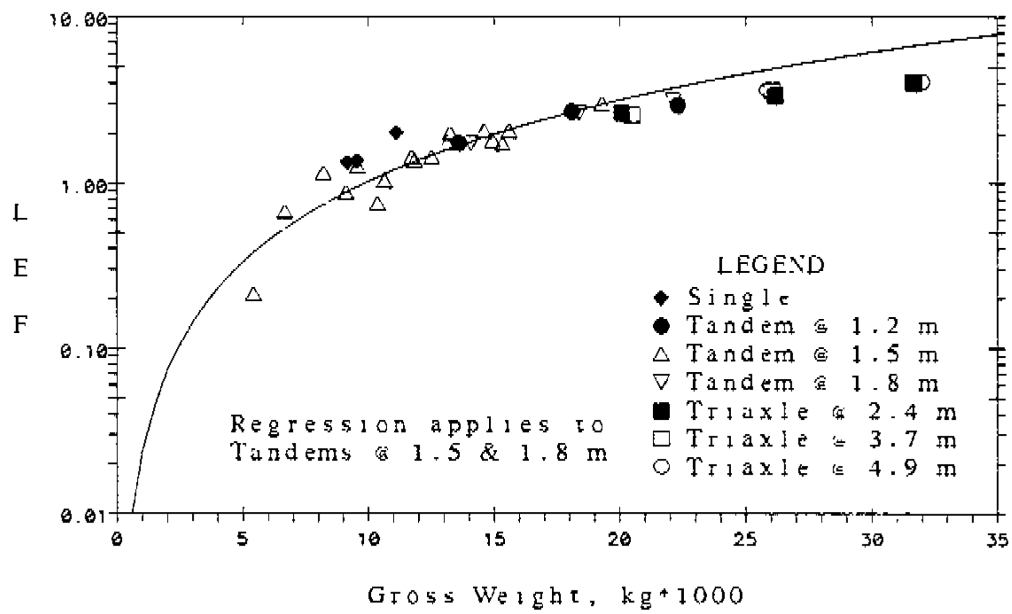


Figure 4.8: Load Equivalency Factors based on Strains: Site 3B, Quebec

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.00216\ (GW)^{2.462}\quad r^2 = 0.98\quad N = 20\quad \ell S_{ey} = 0.056$

Based on Strains:

$F = 0.0240\ (GW)^{1.631}\quad r^2 = 0.87\quad N = 20\quad \ell S_{ey} = 0.097$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12100 kg (9900 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 57 (77) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 100 (104) |
| Triaxle (2.4 m) | 146 (124) |
| Triaxle (3.7 m) | 138 (124) |
| Triaxle (4.9 m) | 132 (128) |

## 4.5 LOAD EQUIVALENCY FACTORS

SITE 4

QUEBEC

**Table 4.5**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 4, Quebec**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections | | | Interfacial Tensile Strains | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Single Axle | | | | | | | | |
| 9182 kg | 1.190 | | | 1.134 | | | 1.937 | 1.613 |
| 11127 kg | 1.386 | | | 1.169 | | | 3.457 | 1.810 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.092 | 0.378 | | 1.210 | 1.310 | | 1.422 | 4.854 |
| 18100 kg | 1.367 | 0.467 | | 1.134 | 1.197 | | 3.336 | 3.593 |
| 22327 kg | 1.639 | 0.555 | | 1.138 | 1.223 | | 6.644 | 3.783 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.503 | 0.242 | | 0.869 | 0.721 | | 0.078 | 0.850 |
| 9109 kg | 0.750 | 0.368 | | 1.149 | 1.083 | | 0.358 | 3.049 |
| 9555 kg | 0.776 | 0.379 | | 1.090 | 1.047 | | 0.407 | 2.578 |
| 10345 kg | 0.838 | 0.419 | | 1.011 | 0.944 | | 0.548 | 1.846 |
| 10645 kg | 0.912 | 0.482 | | 0.978 | 0.939 | | 0.767 | 1.706 |
| 11718 kg | 0.917 | 0.467 | | 1.118 | 1.097 | | 0.775 | 2.949 |
| 11827 kg | 0.936 | 0.468 | | 1.176 | 1.146 | | 0.834 | 3.524 |
| 12500 kg | 0.950 | 0.472 | | 0.995 | 0.982 | | 0.881 | 1.914 |
| 13136 kg | 0.988 | 0.477 | | 1.059 | 1.037 | | 1.015 | 2.391 |
| 13236 kg | 0.983 | 0.476 | | 1.069 | 1.026 | | 0.996 | 2.931 |
| 14582 kg | 1.095 | 0.534 | | 1.064 | 1.030 | | 1.504 | 2.385 |
| 14936 kg | 1.101 | 0.552 | | 1.155 | 1.115 | | 1.546 | 3.241 |
| 15336 kg | 1.076 | 0.526 | | 1.168 | 1.142 | | 1.408 | 3.460 |
| 15582 kg | 1.145 | 0.553 | | 1.219 | 1.130 | | 1.778 | 3.713 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.051 | 0.559 | | 1.172 | 1.158 | | 1.318 | 3.574 |
| 18382 kg | 1.301 | 0.697 | | 1.189 | 1.237 | | 2.972 | 4.175 |
| 22127 kg | 1.444 | 0.797 | | 1.202 | 1.120 | | 4.462 | 3.550 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.084 | 0.422 | 0.315 | 1.091 | 1.036 | 1.079 | 1.409 | 3.871 |
| 26145 kg | 1.361 | 0.546 | 0.421 | 1.062 | 1.099 | 1.123 | 3.364 | 4.243 |
| 31645 kg | 1.615 | 0.699 | 0.566 | 1.030 | 1.084 | 1.121 | 6.552 | 4.021 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 0.971 | 0.610 | 0.538 | 1.107 | 1.223 | 1.154 | 1.142 | 5.344 |
| 26036 kg | 1.090 | 0.717 | 0.650 | 1.184 | 1.228 | 1.116 | 1.864 | 5.600 |
| 31645 kg | 1.319 | 0.839 | 0.793 | 1.128 | 1.192 | 1.180 | 3.791 | 5.406 |

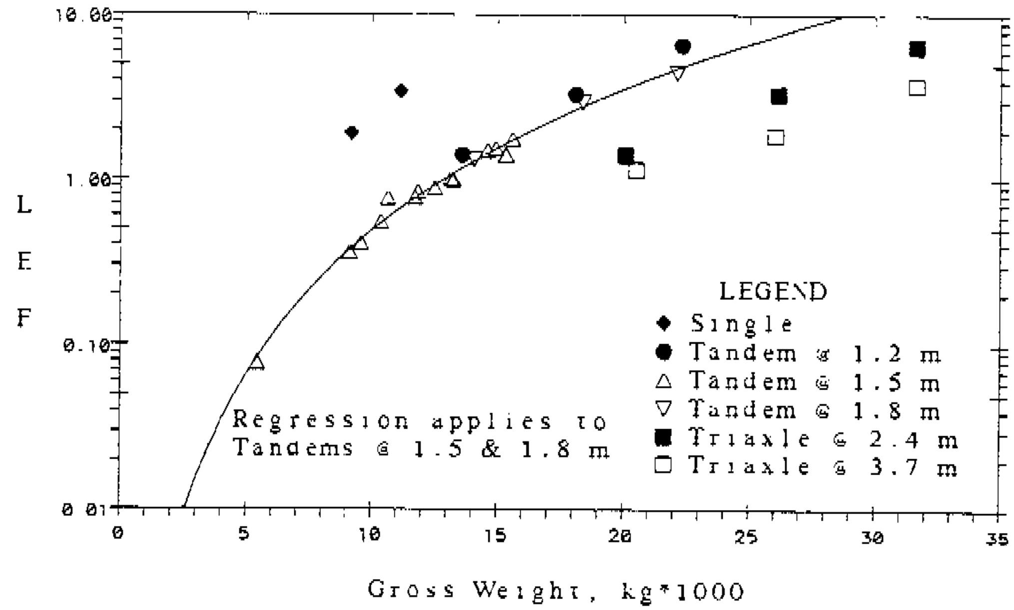


Figure 4.9: Load Equivalency Factors based on Deflections: Site 4, Quebec

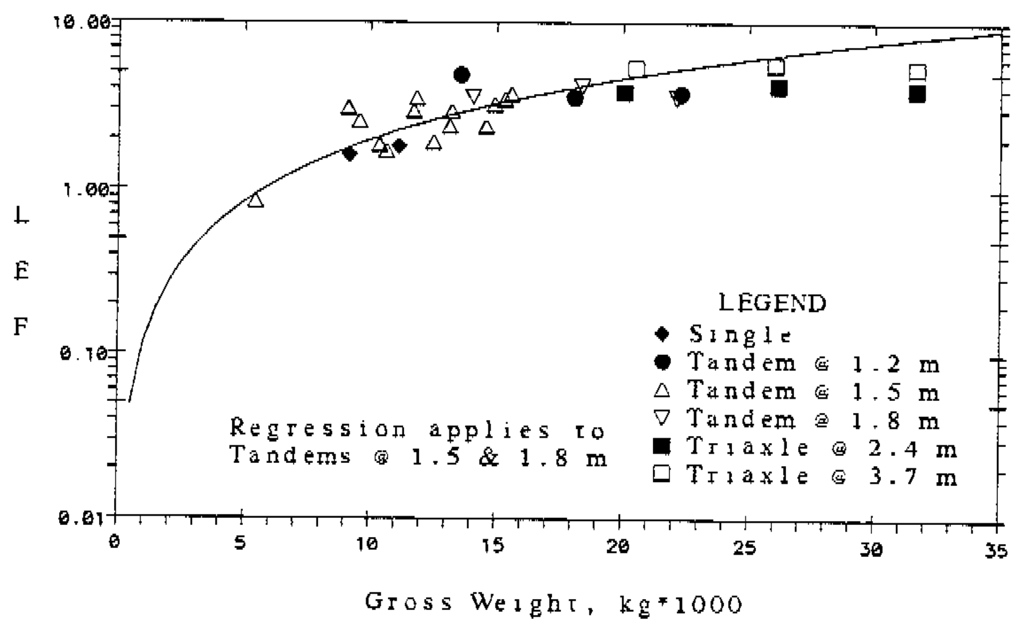


Figure 4.10: Load Equivalency Factors based on Strains: Site 4, Quebec

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.000647\ (GW)^{2.874}$ $r^2 = 0.99$ $N = 17$ $\ell S_{ey} = 0.0408$

Based on Strains:

$F = 0.1149\ (GW)^{1.2318}$ $r^2 = 0.74$ $N = 15$ $\ell S_{ey} = 0.091$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12900 kg (5800 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 57 (100) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 92 (102) |
| Triaxle (2.4 m) | 133 (144) |
| Triaxle (3.7 m) | 156 (114) |

## 4.6 LOAD EQUIVALENCY FACTORS

SITE 5

QUEBEC

**Table 4.6**
**Average Pavement Response Ratios and Load Equivalency Factors, Site 5, Quebec**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Single Axle | | | | | | | | |
| 9182 kg | 1.210 | | | 1.153 | | | 2.006 | 1.178 |
| 11127 kg | 1.344 | | | 1.149 | | | 3.076 | 1.695 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.103 | 0.411 | | 1.263 | 1.138 | | 1.485 | 4.063 |
| 18100 kg | 1.324 | 0.516 | | 1.218 | 1.173 | | 2.986 | 3.949 |
| 22327 kg | 1.534 | 0.532 | | 1.102 | 1.114 | | 5.174 | 2.954 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.501 | 0.232 | | 0.580 | 0.483 | | 0.076 | 0.189 |
| 9109 kg | 0.773 | 0.418 | | 1.106 | 0.982 | | 0.412 | 2.400 |
| 9555 kg | 0.795 | 0.399 | | 0.968 | 0.879 | | 0.449 | 1.496 |
| 10345 kg | 0.853 | 0.419 | | 0.915 | 0.838 | | 0.583 | 1.224 |
| 10645 kg | 0.890 | 0.455 | | 0.915 | 0.855 | | 0.692 | 1.265 |
| 11718 kg | 0.970 | 0.496 | | 1.055 | 0.998 | | 0.960 | 2.218 |
| 11827 kg | 0.914 | 0.500 | | 1.158 | 1.087 | | 0.782 | 3.119 |
| 12500 kg | 0.996 | 0.482 | | 1.060 | 1.084 | | 1.047 | 2.562 |
| 13136 kg | 0.975 | 0.453 | | 1.004 | 0.912 | | 0.958 | 1.720 |
| 13236 kg | 0.984 | 0.477 | | 1.106 | 1.075 | | 1.001 | 2.783 |
| 14582 kg | 1.074 | 0.525 | | 1.223 | 1.131 | | 1.398 | 3.745 |
| 14936 kg | 1.065 | 0.563 | | 1.026 | 0.992 | | 1.383 | 2.072 |
| 15336 kg | 1.054 | 0.494 | | 0.901 | 0.804 | | 1.290 | 1.109 |
| 15682 kg | 1.171 | 0.564 | | 1.025 | 0.929 | | 1.935 | 1.864 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.052 | 0.545 | | 1.227 | 1.178 | | 1.312 | 4.039 |
| 18382 kg | 1.243 | 0.610 | | 1.188 | 1.170 | | 2.438 | 3.740 |
| 22127 kg | 1.424 | 0.774 | | 1.162 | 1.160 | | 4.209 | 3.527 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.146 | 0.503 | 0.386 | 1.060 | 0.921 | 0.987 | 1.779 | 2.931 |
| 26145 kg | 1.323 | 0.561 | 0.426 | 1.214 | 1.178 | 1.202 | 3.047 | 5.966 |
| 31645 kg | 1.499 | 0.675 | 0.527 | 1.143 | 1.220 | 1.197 | 4.969 | 5.771 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 0.928 | 0.568 | 0.512 | 1.063 | 1.118 | 1.023 | 0.948 | 3.835 |
| 26036 kg | 1.088 | 0.729 | 0.655 | 1.213 | 1.221 | 1.158 | 1.879 | 5.965 |
| 31664 kg | 1.255 | 0.781 | 0.691 | 1.173 | 1.213 | 1.151 | 3.007 | 5.623 |

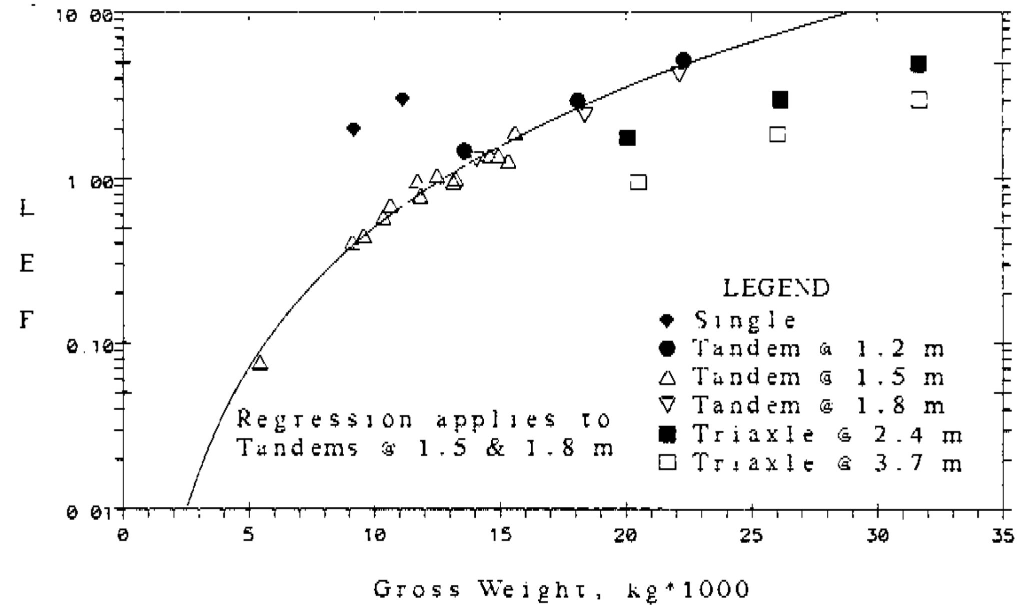


Figure 4.11 Load Equivalency Factors based on Deflections: Site 5, Quebec

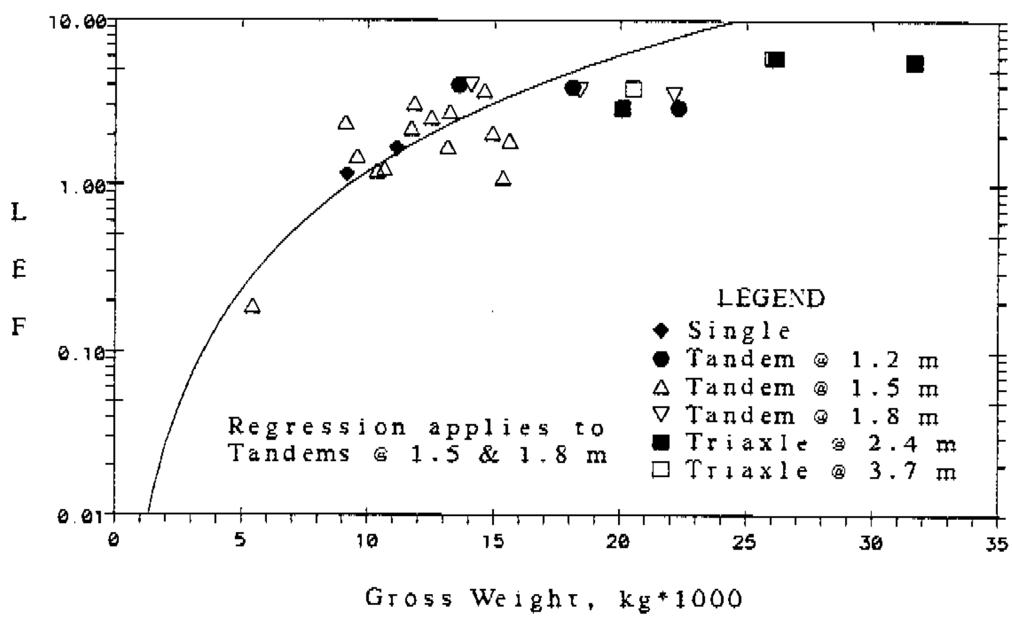


Figure 4.12 Load Equivalency Factors based on Strains: Site 5, Quebec

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.000786\ (GW)^{2.818}$ $r^2 = 0.93$ $N = 17$ $\ell S_{ey} = 0.0974$

Based on Strains:

$F = 0.00528\ (GW)^{2.358}$ $r^2 = 0.78$ $N = 14$ $\ell S_{ey} = 0.156$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12600 kg (9300 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 58 (95) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 97 (114) |
| Triaxle (2.4 m) | 137 (144) |
| Triaxle (3.7 m) | 165 (141) |

## 4.7 LOAD EQUIVALENCY FACTORS

SITE 6

ONTARIO

**Table 4.7**
**Average Pavement Response Ratios and Load Equivalency Factors, Site 6, Ontario**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | Interfacial Tensile Strains $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Load Equivalency Factors Based on Deflections | Strains |
|---|---|---|---|---|---|---|---|---|
| **Steering Axle** | | | | | | | | |
| 3790 kg | 0.837 | | | 1.048 | | | 0.509 | 1.196 |
| 5110 kg | 0.964 | | | 1.245 | | | 0.870 | 2.297 |
| **Single Axle** | | | | | | | | |
| 9182 kg | 1.130 | | | 1.090 | | | 1.591 | 1.387 |
| 9570 kg | 1.170 | | | 1.111 | | | 1.816 | 1.492 |
| 11127 kg | 1.260 | | | 1.165 | | | 2.409 | 1.787 |
| **Tandem Axle (1.2m)** | | | | | | | | |
| 13582 kg | 1.062 | 0.673 | | 1.032 | 0.950 | | 1.481 | 1.950 |
| 18100 kg | 1.208 | 0.736 | | 1.073 | 1.067 | | 2.365 | 2.541 |
| 22327 kg | 1.416 | 0.845 | | 1.094 | 1.032 | | 4.277 | 2.535 |
| **Tandem Axle (1.5m)** | | | | | | | | |
| 5445 kg | 0.481 | 0.317 | | 0.639 | 0.598 | | 0.075 | 0.325 |
| 6682 kg | 0.583 | 0.395 | | 0.784 | 0.719 | | 0.158 | 0.682 |
| 8209 kg | 0.659 | 0.499 | | 0.808 | 0.791 | | 0.276 | 0.854 |
| 9109 kg | 0.661 | 0.521 | | 0.782 | 0.754 | | 0.292 | 0.735 |
| 9565 kg | 0.791 | 0.601 | | 1.001 | 0.952 | | 0.555 | 1.836 |
| 10345 kg | 0.783 | 0.605 | | 0.920 | 0.879 | | 0.543 | 1.339 |
| 10645 kg | 0.808 | 0.591 | | 0.936 | 0.925 | | 0.580 | 1.520 |
| 11718 kg | 0.842 | 0.610 | | 0.961 | 0.930 | | 0.674 | 1.620 |
| 11827 kg | 0.896 | 0.693 | | 1.023 | 0.976 | | 0.907 | 2.001 |
| 12500 kg | 0.984 | 0.723 | | 1.049 | 1.010 | | 1.234 | 2.241 |
| 13136 kg | 0.933 | 0.658 | | 0.969 | 0.949 | | 0.972 | 1.705 |
| 13236 kg | 0.941 | 0.674 | | 1.018 | 0.990 | | 1.016 | 2.034 |
| 14582 kg | 1.034 | 0.801 | | 1.077 | 1.010 | | 1.564 | 2.367 |
| 14936 kg | 1.032 | 0.767 | | 1.109 | 1.056 | | 1.492 | 2.710 |
| 15336 kg | 1.035 | 0.772 | | 1.060 | 1.019 | | 1.514 | 2.325 |
| 15582 kg | 1.088 | 0.818 | | 1.139 | 1.055 | | 1.842 | 2.869 |
| 19280 kg | 1.211 | 0.868 | | 1.131 | 1.068 | | 2.653 | 2.879 |
| **Tandem Axle (1.8m)** | | | | | | | | |
| 14064 kg | 1.098 | 0.802 | | 1.053 | 0.995 | | 1.858 | 2.197 |
| 18382 kg | 1.220 | 0.934 | | 1.073 | 1.062 | | 2.899 | 2.562 |
| 22127 kg | 1.265 | 0.977 | | 1.152 | 1.188 | | 3.357 | 3.638 |
| **Triaxle (2.4m)** | | | | | | | | |
| 20082 kg | 1.067 | 0.683 | 0.653 | 1.022 | 0.934 | 0.930 | 1.712 | 2.616 |
| 26145 kg | 1.182 | 0.724 | 0.688 | 1.007 | 0.972 | 1.005 | 2.425 | 2.946 |
| 31645 kg | 1.319 | 0.798 | 0.768 | 1.152 | 1.116 | 1.168 | 3.652 | 5.036 |
| **Triaxle (3.7m)** | | | | | | | | |
| 20510 kg | 0.958 | 0.796 | 0.828 | 1.066 | 1.027 | 1.010 | 1.756 | 3.420 |
| 26036 kg | 0.996 | 0.831 | 0.834 | 0.976 | 1.022 | 1.067 | 1.979 | 3.277 |
| 31664 kg | 1.130 | 0.940 | 0.960 | 1.046 | 1.032 | 1.060 | 3.235 | 3.561 |
| **Triaxle (4.9m)** | | | | | | | | |
| 25836 kg | 1.010 | 0.888 | 0.940 | 1.076 | 1.015 | 1.057 | 2.467 | 3.615 |
| 31955 kg | 1.194 | 1.064 | 0.990 | 1.162 | 1.098 | 1.077 | 4.189 | 4.523 |

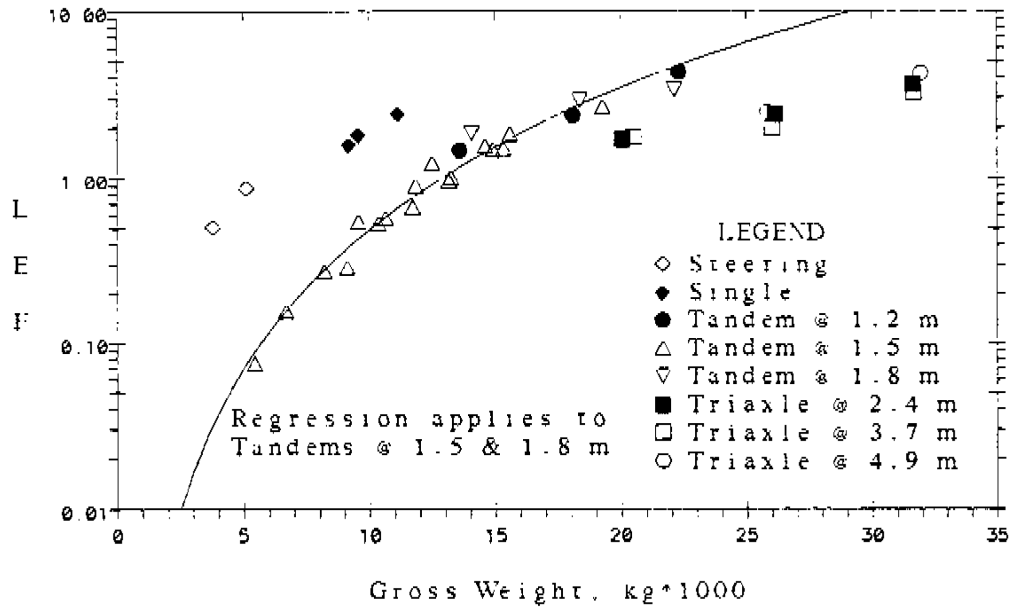


Figure 4.13: Load Equivalency Factors based on Deflections. Site 6, Ontario

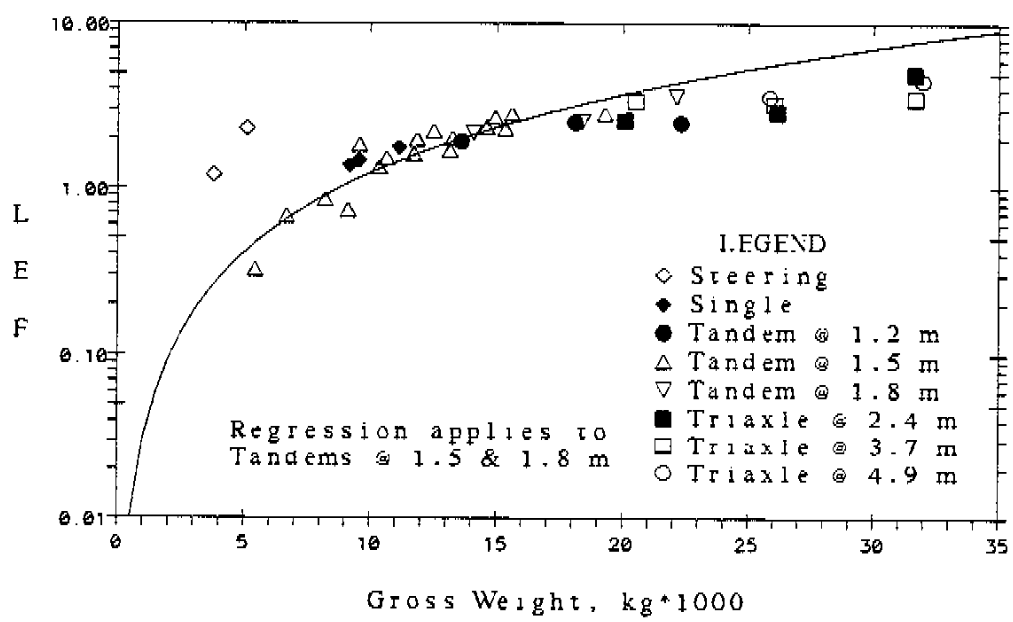


Figure 4.14: Load Equivalency Factors based on Strains: Site 6, Ontario

## A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.000764\ (GW)^{2.809}$ $r^2 = 0.97$ N =20 $S_{ey} = 0.076$

Based on Strains:

$F = 0.0307\ (GW)^{1.603}$ $r^2 = 0.88$ N = 20 $S_{ey} = 0.089$

where: GW = gross weight, kg x $10^3$

## B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights and load applications are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12900 kg (8800 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 61 (85) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 100 (115) |
| Triaxle (2.4 m) | 144 (136) |
| Triaxle (3.7 m) | 150 (138) |
| Triaxle (4.9 m) | 147 (137) |

3. At comparable load magnitudes (approximately 5000 kg), one application of a single steering axle is equivalent in potential damaging effect to approximately 12 (7) applications of tandem axle (1.5 -1.8 m) - dual tire configuration.

## 4.8 LOAD EQUIVALENCY FACTORS

SITE 7

ONTARIO

**Table 4.8**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 7, Ontario**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections | | | Average Pavement Response Ratios: Interfacial Tensile Strains | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| **Single Axle** | | | | | | | | |
| 9182 kg | 1.163 | | | 1.020 | | | 1.775 | 1.078 |
| 11127 kg | 1.294 | | | 1.137 | | | 2.663 | 1.629 |
| **Tandem Axle (1.2m)** | | | | | | | | |
| 13682 kg | 1.002 | 0.453 | | 0.791 | 0.776 | | 1.057 | 0.792 |
| 22327 kg | 1.438 | 0.627 | | 1.181 | 1.150 | | 4.146 | 3.582 |
| **Tandem Axle (1.5m)** | | | | | | | | |
| 5445 kg | 0.452 | 0.247 | | 0.376 | 0.361 | | 0.064 | 0.045 |
| 9565 kg | 0.735 | 0.447 | | 0.683 | 0.675 | | 0.357 | 0.459 |
| 10645 kg | 0.795 | 0.449 | | 0.683 | 0.666 | | 0.466 | 0.448 |
| 11718 kg | 0.810 | 0.474 | | 0.768 | 0.765 | | 0.508 | 0.728 |
| 12500 kg | 0.830 | 0.546 | | 0.841 | 0.826 | | 0.593 | 1.002 |
| 13136 kg | 0.932 | 0.619 | | 0.893 | 0.885 | | 0.927 | 1.279 |
| 13236 kg | 0.945 | 0.624 | | 0.899 | 0.866 | | 0.973 | 1.246 |
| 14582 kg | 1.006 | 0.620 | | 0.933 | 0.906 | | 1.186 | 1.456 |
| 15336 kg | 1.024 | 0.600 | | 0.958 | 0.934 | | 1.238 | 1.621 |
| 15682 kg | 1.000 | 0.538 | | 0.939 | 0.917 | | 1.095 | 1.507 |
| **Tandem Axle (1.8m)** | | | | | | | | |
| 14064 kg | 0.970 | 0.701 | | 0.842 | 0.870 | | 1.150 | 1.109 |
| 22127 kg | 1.228 | 0.820 | | 1.129 | 1.179 | | 2.653 | 3.456 |
| **Triaxle (2.4m)** | | | | | | | | |
| 20082 kg | 0.937 | 0.414 | 0.366 | 0.759 | 0.660 | 0.755 | 0.838 | 0.901 |
| 31645 kg | 1.297 | 0.520 | 0.427 | 1.062 | 0.986 | 1.025 | 2.809 | 3.259 |
| **Triaxle (3.7m)** | | | | | | | | |
| 20509 kg | 0.861 | 0.636 | 0.645 | 0.781 | 0.798 | 0.866 | 0.934 | 1.394 |
| 31664 kg | 1.098 | 0.827 | 0.799 | 1.033 | 1.109 | 1.156 | 2.339 | 4.348 |

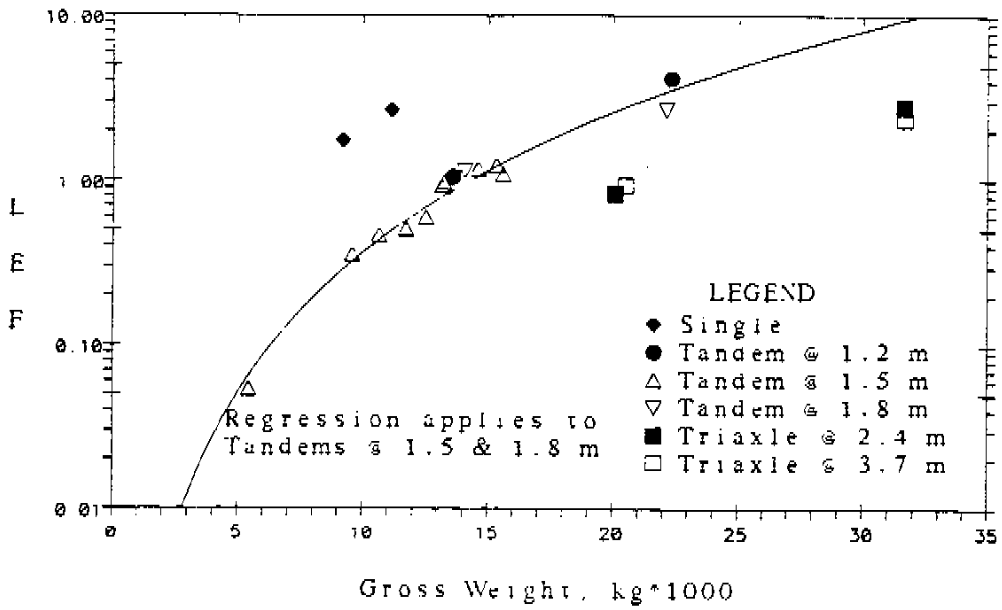


Figure 4.15: Load Equivalency Factors based on Deflections: Site 7, Ontario

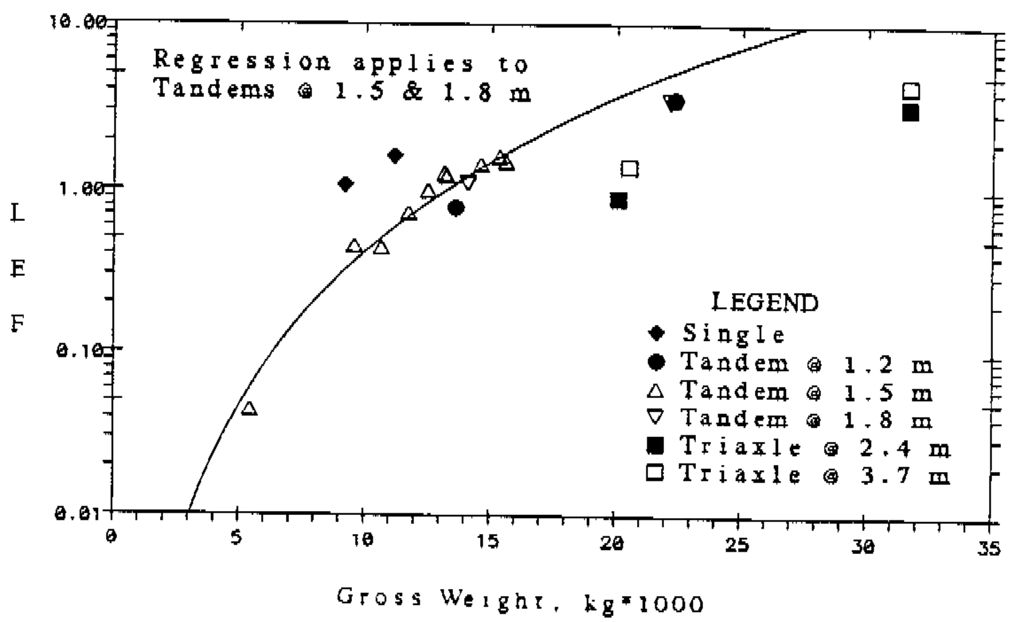


Figure 4.16: Load Equivalency Factors based on Strains: Site 7, Ontario

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.000537\ (GW)^{2.831}\quad r^2 = 0.98\quad N = 12\quad \ell S_{ey} = 0.070$

Based on Strains:

$F = 0.0003\ (GW)^{3.143}\quad r^2 = 0.96\quad N = 12\quad \ell S_{ey} = 0.092$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 14300 kg (13200 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 53 (70) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 94 (111) |
| Triaxle (2.4 m) | 152 (161) |
| Triaxle (3.7 m) | 155 (145) |

## 4.9 LOAD EQUIVALENCY FACTORS

SITE 8

ONTARIO

**Table 4.9**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 8, Ontario**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | Interfacial Tensile Strains $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Load Equivalency Factors Based on Deflections | Strains |
|---|---|---|---|---|---|---|---|---|
| Single Axle | | | | | | | | |
| 9182 kg | 1.016 | | | 1.010 | | | 1.063 | 1.040 |
| 11127 kg | 1.215 | | | 1.159 | | | 2.098 | 1.754 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 0.898 | 0.273 | | 0.786 | 0.777 | | 0.672 | 0.784 |
| 22327 kg | 1.289 | 0.605 | | 1.134 | 1.126 | | 2.772 | 3.182 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.420 | 0.228 | | 0.384 | 0.390 | | 0.041 | 0.054 |
| 9555 kg | 0.635 | 0.294 | | 0.607 | 0.581 | | 0.188 | 0.277 |
| 10645 kg | 0.710 | 0.411 | | 0.706 | 0.689 | | 0.306 | 0.509 |
| 11718 kg | 0.788 | 0.433 | | 0.734 | 0.733 | | 0.445 | 0.615 |
| 12500 kg | 0.766 | 0.361 | | 0.745 | 0.738 | | 0.385 | 0.641 |
| 13136 kg | 0.839 | 0.390 | | 0.785 | 0.781 | | 0.542 | 0.789 |
| 13236 kg | 0.824 | 0.410 | | 0.774 | 0.775 | | 0.513 | 0.757 |
| 14582 kg | 0.907 | 0.464 | | 0.876 | 0.879 | | 0.743 | 1.217 |
| 15336 kg | 0.924 | 0.603 | | 0.882 | 0.887 | | 0.886 | 1.254 |
| 15582 kg | 0.990 | 0.477 | | 0.941 | 0.969 | | 1.024 | 1.645 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 0.834 | 0.509 | | 0.815 | 0.875 | | 0.579 | 1.062 |
| 22127 kg | 1.255 | 0.822 | | 1.119 | 1.199 | | 2.845 | 3.526 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 0.913 | 0.323 | 0.294 | 0.758 | 0.731 | 0.831 | 0.732 | 1.149 |
| 31645 kg | 1.210 | 0.511 | 0.461 | 1.073 | 1.024 | 1.114 | 2.190 | 3.909 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 0.744 | 0.486 | 0.463 | 0.717 | 0.792 | 0.850 | 0.443 | 1.235 |
| 31664 kg | 1.031 | 0.828 | 0.808 | 0.976 | 1.080 | 1.151 | 2.057 | 3.961 |

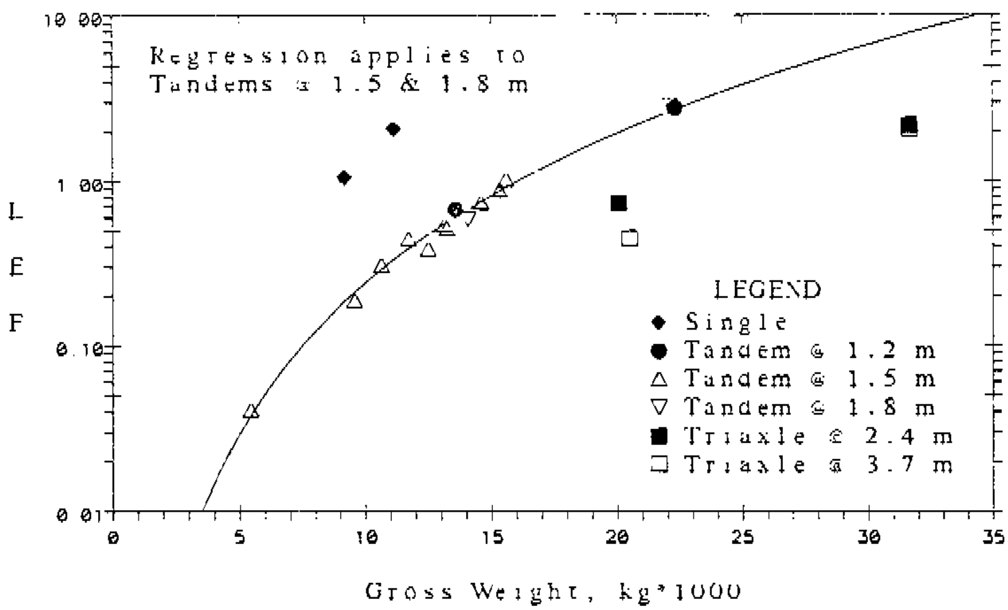


Figure 4.17 Load Equivalency Factors based on Deflections: Site 8, Ontario

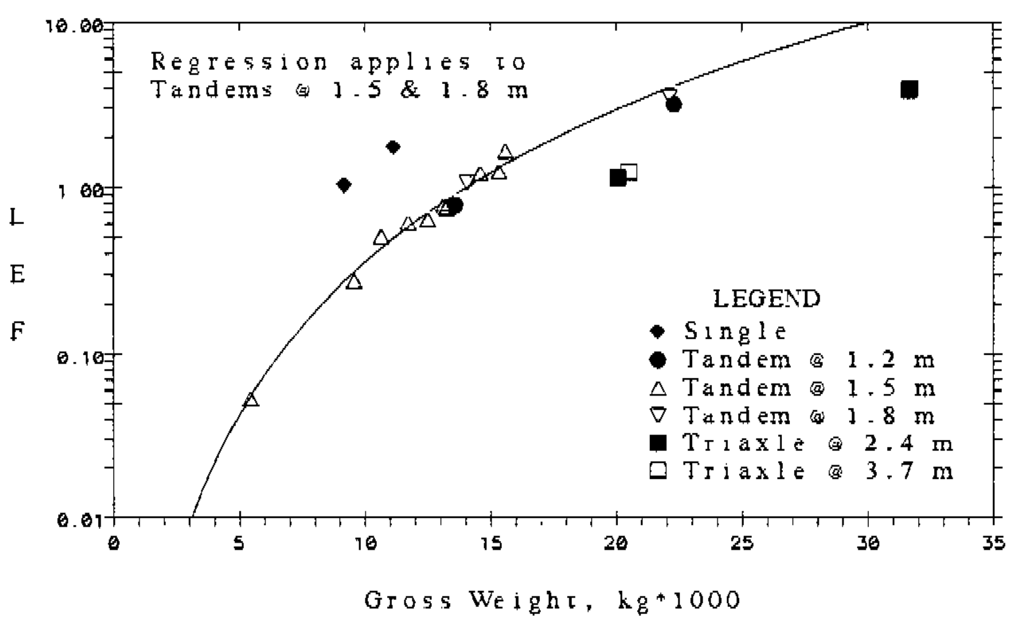


Figure 4.18 Load Equivalency Factors based on Strains: Site 8, Ontario

## A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.00023\ (GW)^{3.020}\quad r^2 = 0.99\quad N = 12\quad \%S_{ey} = 0.046$

Based on Strains:

$F = 0.000322\ (GW)^{3.043}\quad r^2 = 0.99\quad N = 12\quad \%S_{ey} = 0.046$

where: GW = gross weight, kg x $10^3$

## B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 16100 kg (14100 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 55 (65) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 98 (106) |
| Triaxle (2.4 m) | 145 (140) |
| Triaxle (3.7 m) | 162 (140) |

## 4.10 LOAD EQUIVALENCY FACTORS

SITE 9

ALBERTA

**Table 4.10**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 9, Alberta**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections | | | Interfacial Tensile Strains | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Steering Axle | | | | | | | | |
| 3790 kg | 0.590 | | | 0.895 | | | 0.135 | 0.656 |
| 5110 kg | 0.778 | | | 1.070 | | | 0.385 | 1.293 |
| Single Axle | | | | | | | | |
| 9182 kg | 1.107 | | | 1.087 | | | 1.472 | 1.373 |
| 9570 kg | 1.319 | | | 1.083 | | | 2.864 | 1.354 |
| 11127 kg | 1.367 | | | 1.207 | | | 3.280 | 2.044 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.106 | 0.334 | | 0.984 | 0.814 | | 1.482 | 1.398 |
| 18100 kg | 1.455 | 0.384 | | 1.079 | 0.875 | | 4.184 | 1.937 |
| 22327 kg | 1.657 | 0.449 | | 1.223 | 1.035 | | 6.862 | 3.289 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.578 | 0.331 | | 0.568 | 0.503 | | 0.140 | 0.182 |
| 6682 kg | 0.718 | 0.433 | | 0.708 | 0.642 | | 0.326 | 0.456 |
| 8209 kg | 0.682 | 0.327 | | 0.724 | 0.658 | | 0.248 | 0.497 |
| 9109 kg | 0.784 | 0.389 | | 0.808 | 0.744 | | 0.424 | 0.770 |
| 9555 kg | 0.810 | 0.349 | | 0.851 | 0.707 | | 0.467 | 0.809 |
| 10345 kg | 0.839 | 0.508 | | 0.868 | 0.826 | | 0.589 | 1.120 |
| 10645 kg | 0.958 | 0.573 | | 0.978 | 0.940 | | 0.970 | 1.709 |
| 11718 kg | 0.872 | 0.413 | | 0.884 | 0.798 | | 0.629 | 1.050 |
| 11827 kg | 0.857 | 0.388 | | 0.880 | 0.810 | | 0.584 | 1.064 |
| 12500 kg | 0.943 | 0.415 | | 0.995 | 0.856 | | 0.835 | 1.535 |
| 13136 kg | 1.006 | 0.472 | | 0.931 | 0.863 | | 1.081 | 1.333 |
| 13236 kg | 0.960 | 0.455 | | 0.968 | 0.872 | | 0.906 | 1.478 |
| 14582 kg | 1.100 | 0.442 | | 1.092 | 0.946 | | 1.436 | 1.478 |
| 14936 kg | 1.145 | 0.443 | | 1.067 | 0.973 | | 1.718 | 2.181 |
| 15336 kg | 1.105 | 0.569 | | 1.046 | 0.985 | | 1.579 | 2.131 |
| 15582 kg | 1.173 | 0.565 | | 1.113 | 1.041 | | 1.948 | 2.667 |
| 19280 kg | 1.389 | 0.564 | | 1.204 | 1.035 | | 3.599 | 3.164 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.036 | 0.470 | | 1.010 | 0.888 | | 1.201 | 1.675 |
| 18382 kg | 1.219 | 0.564 | | 1.080 | 1.023 | | 2.236 | 2.430 |
| 22127 kg | 1.427 | 0.632 | | 1.204 | 1.178 | | 4.037 | 3.868 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.160 | 0.462 | 0.385 | 0.917 | 0.729 | 0.733 | 1.837 | 1.327 |
| 26145 kg | 1.297 | 0.556 | 0.472 | 1.131 | 0.922 | 0.934 | 2.852 | 3.102 |
| 31645 kg | 1.583 | 0.650 | 0.515 | 1.181 | 1.033 | 1.029 | 6.003 | 4.128 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 1.015 | 0.557 | 0.458 | 0.903 | 0.881 | 0.821 | 1.218 | 1.769 |
| 26036 kg | 1.182 | 0.656 | 0.633 | 0.977 | 0.992 | 0.996 | 2.265 | 2.870 |
| 31664 kg | 1.328 | 0.805 | 0.788 | 1.123 | 1.151 | 1.117 | 3.782 | 4.783 |
| Triaxle (4.9m) | | | | | | | | |
| 25836 kg | 1.106 | 0.849 | 0.628 | 1.040 | 1.022 | 1.012 | 1.466 | 3.298 |
| 31955 kg | 1.289 | 0.981 | 0.791 | 1.165 | 1.102 | 1.126 | 3.964 | 4.803 |

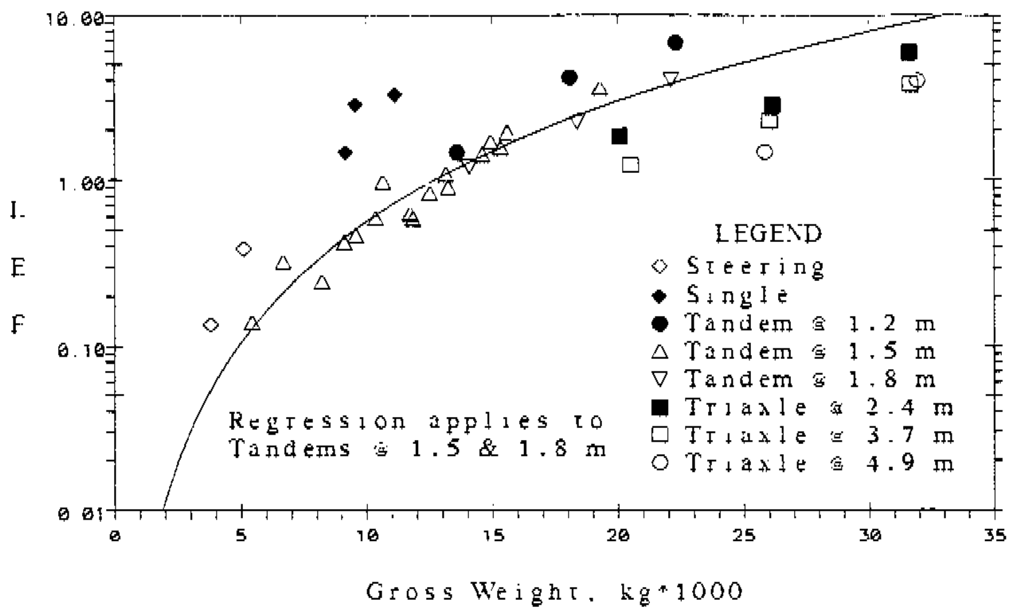


Figure4.19 Load Equivalency Factors based on Deflections: Site 9, Alberta

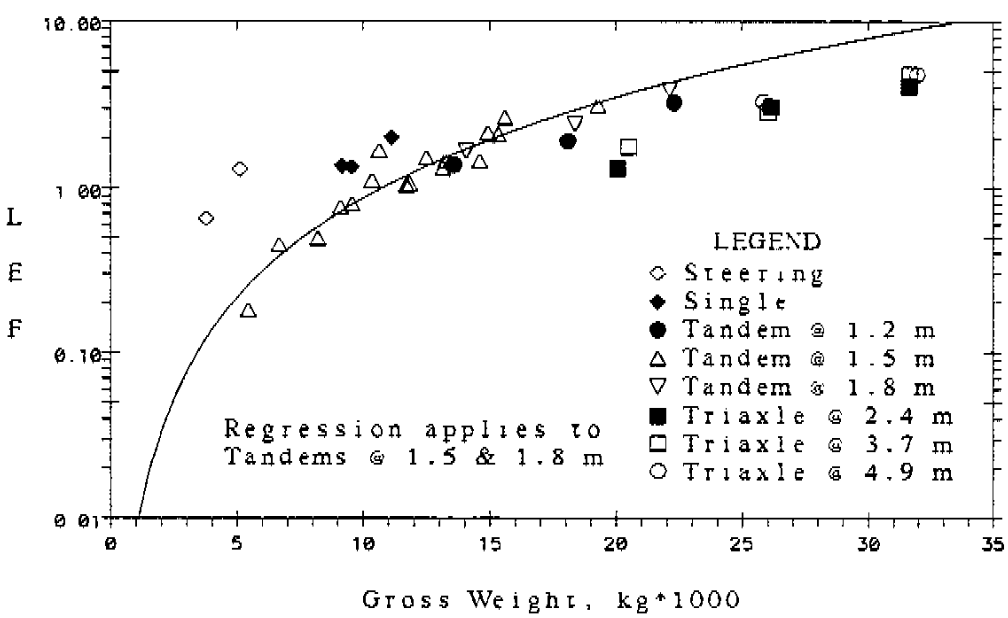


Figure4.20: Load Equivalency Factors based on Strains: Site 9, Alberta

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.00218\ (GW)^{2.411}$ $r^2 = 0.94$ $N = 20$ $\ell S_{ey} = 0.094$

Based on Strains:

$F = 0.00845\ (GW)^{2.012}$ $r^2 = 0.93$ $N = 20$ $\ell S_{ey} = 0.086$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights and load applications are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12700 kg (10700 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 55 (73) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 83 (114) |
| Triaxle (2.4 m) | 125 (150) |
| Triaxle (3.7 m) | 146 (141) |
| Triaxle (4.9 m) | 157 (135) |

3. At comparable load magnitudes (approximately 5000 kg), one application of a single steering axle is equivalent in potential damaging effect to approximately 4 (7) applications of tandem axle (1.5 -1.8 m) - dual tire configuration.

## 4.11 LOAD EQUIVALENCY FACTORS

SITE 10

ALBERTA

**Table 4.11**
**Average Pavement Response Ratios and Load Equivalency Factors, Site 10, Alberta**

| Loading Condition | Average Pavement Response Ratios: Pavement Surface Deflections | | | Interfacial Tensile Strains | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| **Steering Axle** | | | | | | | | |
| 3790 kg | 0.710 | | | 1.048 | | | 0.272 | 1.196 |
| 5110 kg | 0.880 | | | 1.196 | | | 0.615 | 1.974 |
| **Single Axle** | | | | | | | | |
| 9182 kg | 1.154 | | | 1.103 | | | 1.723 | 1.451 |
| 9570 kg | 1.254 | | | 1.185 | | | 2.363 | 1.906 |
| 11127 kg | 1.268 | | | 1.313 | | | 2.466 | 2.815 |
| **Tandem Axle (1.2m)** | | | | | | | | |
| 13582 kg | 1.089 | 0.489 | | 1.001 | 0.970 | | 1.449 | 1.895 |
| 18100 kg | 1.324 | 0.471 | | 1.092 | 1.040 | | 2.962 | 2.558 |
| 22327 kg | 1.584 | 0.513 | | 1.280 | 1.154 | | 5.821 | 4.278 |
| **Tandem Axle (1.5m)** | | | | | | | | |
| 5446 kg | 0.521 | 0.306 | | 0.545 | 0.515 | | 0.095 | 0.180 |
| 6682 kg | 0.597 | 0.383 | | 0.655 | 0.654 | | 0.167 | 0.399 |
| 8209 kg | 0.647 | 0.397 | | 0.739 | 0.704 | | 0.221 | 0.580 |
| 9109 kg | 0.689 | 0.401 | | 0.779 | 0.739 | | 0.274 | 0.704 |
| 9555 kg | 0.744 | 0.486 | | 0.887 | 0.877 | | 0.390 | 1.241 |
| 10345 kg | 0.825 | 0.450 | | 0.767 | 0.762 | | 0.530 | 0.721 |
| 10646 kg | 0.846 | 0.481 | | 0.860 | 0.820 | | 0.592 | 1.034 |
| 11718 kg | 0.832 | 0.431 | | 0.867 | 0.833 | | 0.538 | 1.081 |
| 11827 kg | 0.887 | 0.528 | | 0.907 | 0.906 | | 0.722 | 1.377 |
| 12500 kg | 0.969 | 0.602 | | 1.030 | 1.007 | | 1.033 | 2.146 |
| 13136 kg | 0.961 | 0.516 | | 0.954 | 0.925 | | 0.941 | 1.580 |
| 13236 kg | 0.959 | 0.508 | | 0.940 | 0.884 | | 0.929 | 1.416 |
| 14582 kg | 1.037 | 0.628 | | 1.122 | 1.107 | | 1.319 | 3.020 |
| 14936 kg | 1.071 | 0.540 | | 1.061 | 1.028 | | 1.394 | 2.319 |
| 15336 kg | 1.064 | 0.568 | | 1.000 | 0.970 | | 1.382 | 1.891 |
| 15582 kg | 1.140 | 0.592 | | 1.102 | 1.045 | | 1.782 | 2.628 |
| 19280 kg | 1.269 | 0.759 | | 1.223 | 1.215 | | 2.823 | 4.245 |
| **Tandem Axle (1.8m)** | | | | | | | | |
| 14064 kg | 1.079 | 0.646 | | 1.049 | 0.996 | | 1.525 | 2.184 |
| 18382 kg | 1.268 | 0.741 | | 1.124 | 1.117 | | 2.786 | 3.062 |
| 22127 kg | 1.313 | 0.763 | | 1.287 | 1.243 | | 3.172 | 4.673 |
| **Triaxle (2.4m)** | | | | | | | | |
| 20082 kg | 1.134 | 0.440 | 0.371 | 0.917 | 0.791 | 0.843 | 1.680 | 1.652 |
| 26145 kg | 1.346 | 0.589 | 0.472 | 1.044 | 0.897 | 0.974 | 3.284 | 2.744 |
| 31645 kg | 1.544 | 0.683 | 0.571 | 1.193 | 1.042 | 1.122 | 5.564 | 4.673 |
| **Triaxle (3.7m)** | | | | | | | | |
| 20509 kg | 0.932 | 0.626 | 0.620 | 0.994 | 1.027 | 0.997 | 1.096 | 3.073 |
| 26036 kg | 1.069 | 0.742 | 0.718 | 1.032 | 1.111 | 1.115 | 1.894 | 4.131 |
| 31664 kg | 1.296 | 0.912 | 0.897 | 1.165 | 1.211 | 1.233 | 4.037 | 6.073 |
| **Triaxle (4.9m)** | | | | | | | | |
| 25836 kg | 1.044 | 0.887 | 0.682 | 1.066 | 1.117 | 1.135 | 2.045 | 4.416 |
| 31955 kg | 1.299 | 1.097 | 0.952 | 1.207 | 1.232 | 1.191 | 4.953 | 6.197 |

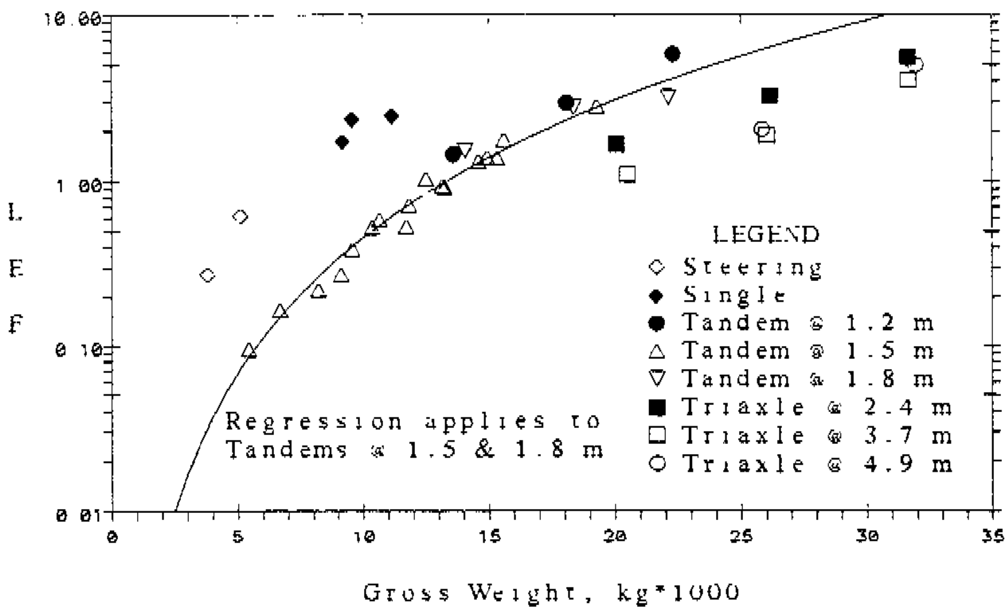


Figure 4.21: Load Equivalency Factors based on Deflections: Site 10, Alberta

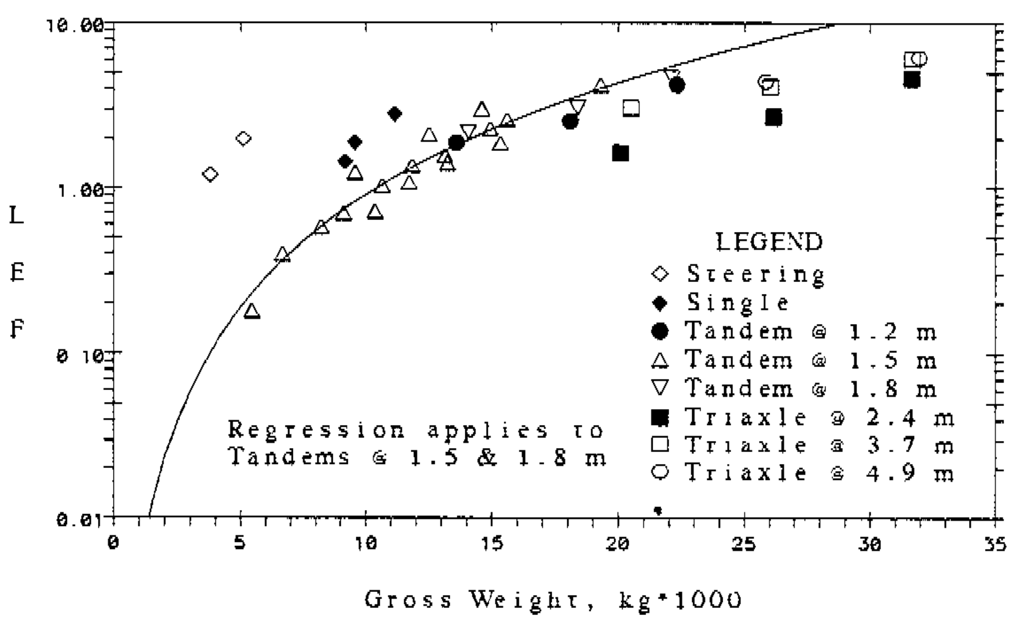


Figure 4.22 Load Equivalency Factors based on Strains: Site 10, Alberta

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.00083\ (GW)^{2.740}$ $r^2 = 0.98$ $N = 20$ $\ell S_{ey} = 0.067$

Based on Strains:

$F = 0.0049\ (GW)^{2.260}$ $r^2 = 0.94$ $N = 20$ $\ell S_{ey} = 0.088$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights and load applications are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 13300 kg (10400 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 57 (70) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 89 (108) |
| Triaxle (2.4 m) | 127 (156) |
| Triaxle (3.7 m) | 149 (130) |
| Triaxle (4.9 m) | 141 (133) |

3. At comparable load magnitudes (approximately 5000 kg), one application of a single steering axle is equivalent in potential damaging effect to approximately 8 (10) applications of tandem axle (1.5 -1.8 m) - dual tire configuration.

## 4.12 LOAD EQUIVALENCY FACTORS

SITE 11

BRITISH COLUMBIA

**Table 4.12**
**Average Pavement Response Ratios and Load Equivalency Factors, Site 11, British Columbia**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Single Axle | | | | | | | | |
| 9182 kg | 1.110 | | | | | | 1.487 | |
| 11127 kg | 1.228 | | | | | | 2.182 | |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 0.972 | 0.423 | | | | | 0.936 | |
| 22327 kg | 1.417 | 0.663 | | | | | 3.970 | |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.455 | 0.368 | | | | | 0.073 | |
| 9565 kg | 0.747 | 0.431 | | | | | 0.371 | |
| 10645 kg | 0.787 | 0.487 | | | | | 0.467 | |
| 11718 kg | 0.860 | 0.565 | | | | | 0.653 | |
| 12500 kg | 0.893 | 0.530 | | | | | 0.740 | |
| 13136 kg | 0.929 | 0.579 | | | | | 0.881 | |
| 13236 kg | 0.937 | 0.599 | | | | | 0.923 | |
| 14582 kg | 1.013 | 0.580 | | | | | 1.176 | |
| 15336 kg | 1.007 | 0.633 | | | | | 1.203 | |
| 15582 kg | 1.060 | 0.680 | | | | | 1.435 | |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 0.943 | 0.630 | | | | | 0.973 | |
| 22127 kg | 1.249 | 0.908 | | | | | 3.021 | |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.027 | 0.531 | 0.506 | | | | 1.272 | |
| 31645 kg | 1.356 | 0.635 | 0.575 | | | | 3.481 | |
| Triaxle (3.7m) | | | | | | | | |
| 20609 kg | 0.904 | 0.616 | 0.605 | | | | 0.988 | |
| 31664 kg | 1.184 | 0.864 | 0.862 | | | | 3.042 | |

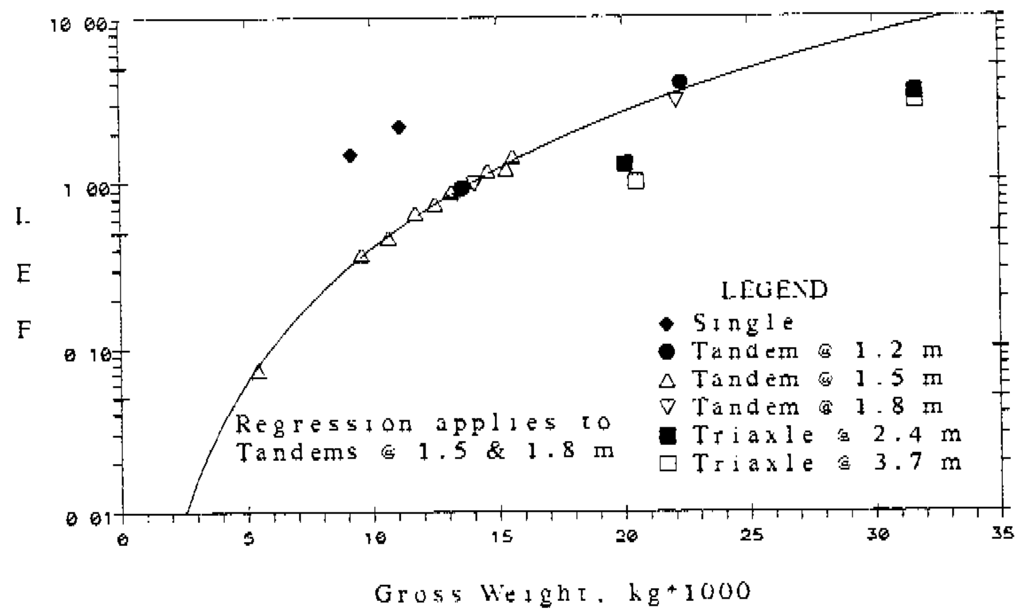


Figure 4.23: Load Equivalency Factors based on Deflections: Site 11, British Columbia

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.00083\ (GW)^{2.687}\quad r^2 = 0.49\quad N = 12\quad S_{ey} = 0.028$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 14000 kg tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 58 percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 97 |
| Triaxle (2.4 m) | 136 |
| Triaxle (3.7 m) | 147 |

# 4.13 LOAD EQUIVALENCY FACTORS

SITE 12

BRITISH COLUMBIA

**Table 4.13**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 12, British Columbia**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Steering Axle | | | | | | | | |
| 3790 kg | 1.004 | | | 1.137 | | | 1.015 | 1.629 |
| 5110 kg | 1.069 | | | 1.216 | | | 1.289 | 2.103 |
| Single Axle | | | | | | | | |
| 9182 kg | 1.072 | | | 1.280 | | | 1.302 | 2.556 |
| 11127 kg | 1.134 | | | 1.106 | | | 1.613 | 1.466 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 kg | 1.018 | 0.777 | | 1.254 | 1.307 | | 1.453 | 5.129 |
| 18100 kg | 1.074 | 0.761 | | 1.336 | 1.269 | | 1.666 | 5.479 |
| 22327 kg | 1.241 | 0.882 | | 1.246 | 1.243 | | 2.692 | 4.592 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 kg | 0.458 | 0.441 | | 0.753 | 0.735 | | 0.096 | 0.651 |
| 9109 kg | 0.736 | 0.682 | | 0.676 | 0.749 | | 0.546 | 0.559 |
| 9555 kg | 0.874 | 0.759 | | 0.923 | 1.017 | | 0.950 | 1.804 |
| 10345 kg | 0.844 | 0.760 | | 0.897 | 0.940 | | 0.877 | 1.452 |
| 10645 kg | 0.779 | 0.696 | | 1.011 | 1.039 | | 0.639 | 2.199 |
| 11718 kg | 0.923 | 0.783 | | 1.192 | 1.188 | | 1.132 | 3.874 |
| 11827 kg | 0.776 | 0.676 | | 1.110 | 1.153 | | 0.607 | 3.204 |
| 12500 kg | 0.914 | 0.791 | | 1.214 | 1.210 | | 1.121 | 4.153 |
| 13136 kg | 0.856 | 0.743 | | 1.061 | 1.036 | | 0.877 | 2.352 |
| 13236 kg | 0.921 | 0.770 | | 1.166 | 1.181 | | 1.102 | 3.794 |
| 14582 kg | 0.981 | 0.838 | | 1.173 | 1.211 | | 1.441 | 3.904 |
| 14936 kg | 0.857 | 0.731 | | 1.273 | 1.273 | | 0.860 | 5.006 |
| 15336 kg | 0.991 | 0.927 | | 1.189 | 1.169 | | 1.716 | 3.741 |
| 15582 kg | 0.955 | 0.854 | | 1.099 | 1.099 | | 1.388 | 2.863 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.040 | 0.885 | | 1.234 | 1.218 | | 1.789 | 4.339 |
| 18382 kg | 1.076 | 0.860 | | 1.323 | 1.318 | | 1.885 | 5.752 |
| 22127 kg | 1.229 | 1.017 | | 1.071 | 1.020 | | 3.255 | 2.376 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.087 | 0.821 | 0.794 | 1.063 | 1.035 | 1.049 | 2.262 | 3.600 |
| 26145 kg | 1.114 | 0.836 | 0.792 | 1.222 | 1.185 | 1.177 | 2.426 | 5.906 |
| 31645 kg | 1.155 | 0.841 | 0.817 | 1.219 | 1.194 | 1.175 | 2.711 | 5.930 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 1.013 | 0.895 | 0.888 | 1.180 | 1.157 | 1.209 | 2.343 | 5.673 |
| 26036 kg | 1.063 | 0.957 | 0.937 | 1.105 | 1.118 | 1.124 | 2.888 | 4.549 |
| 31664 kg | 1.111 | 1.004 | 1.007 | 1.212 | 1.137 | 1.115 | 3.534 | 5.218 |

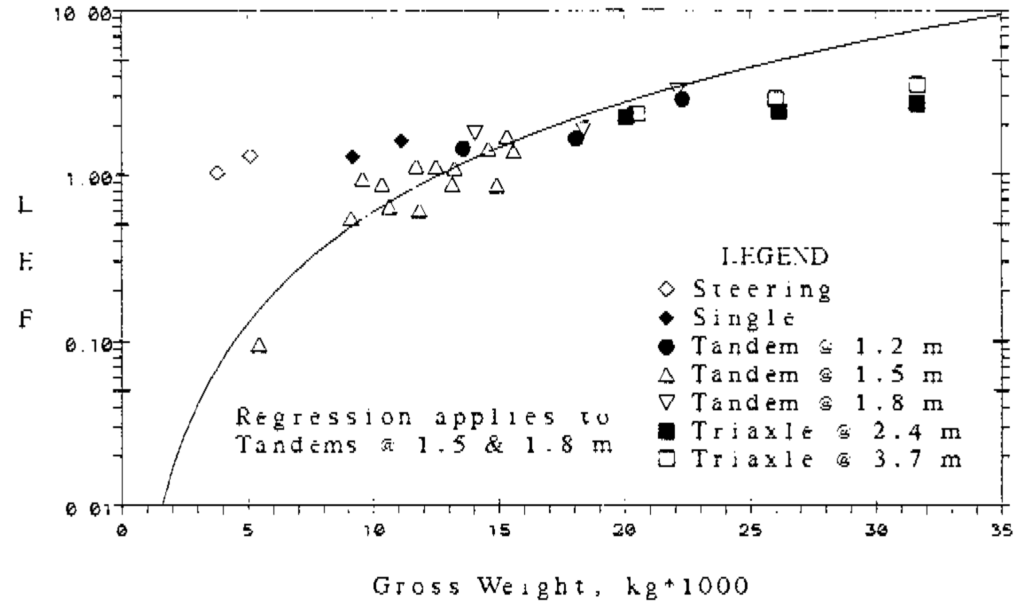


Figure 4.24: Load Equivalency Factors based on Deflections: Site 12, British Columbia

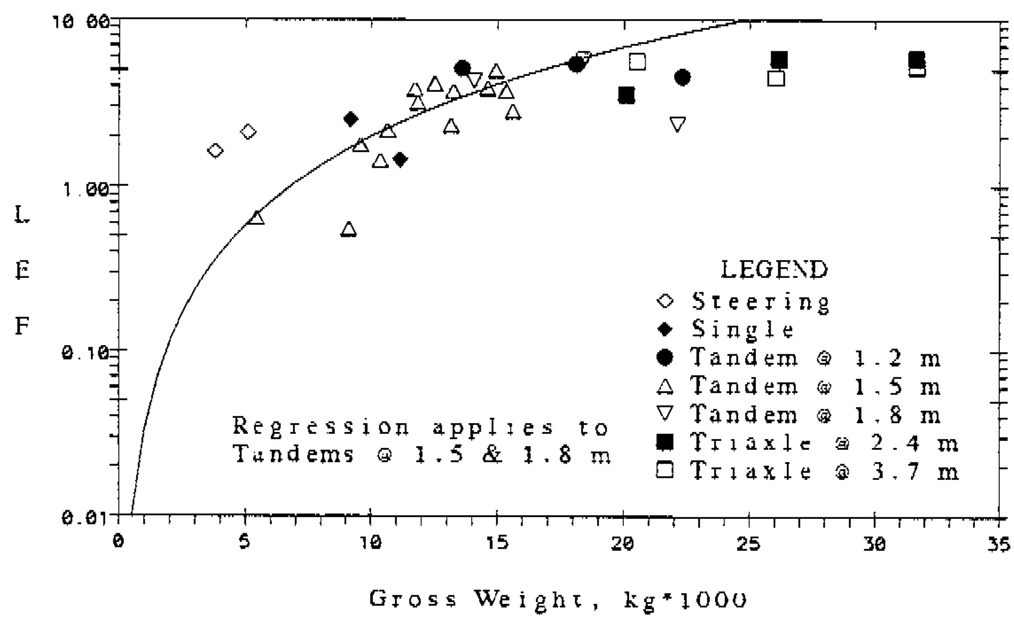


Figure 4.25: Load Equivalency Factors based on Strains: Site 12, British Columbia

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = .00369\ (GW)^{2.207}\quad r^2 = 0.84\quad N = 17\quad \ell S_{ey} = 0.129$

Based on Strains:

$F = 0.0336\ (GW)^{1.776}\quad r^2 = 0.81\quad N = 15\quad \ell S_{ey} = 0.106$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights and load applications are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12700 kg (6800 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 67 (80) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 104 (107) |
| Triaxle (2.4 m) | 136 (143) |
| Triaxle (3.7 m) | 126 (154) |

3. At comparable load magnitudes (approximately 5000 kg), one application of a single steering axle is equivalent in potential damaging effect to approximately 13 (4) applications of tandem axle (1.5 -1.8 m) - dual tire configuration.

## 4.14 LOAD EQUIVALENCY FACTORS

SITE 13

BRITISH COLUMBIA

**Table 4.14**
**Average Pavement Response Ratios and**
**Load Equivalency Factors,**
**Site 13, British Columbia**

| Loading Condition | Average Pavement Response Ratios | | | | | | Load Equivalency Factors Based on | |
|---|---|---|---|---|---|---|---|---|
| | Pavement Surface Deflections | | | Interfacial Tensile Strains | | | | |
| | $D_1/D_b$ | $\Delta_1/D_b$ | $\Delta_2/D_b$ | $S_1/S_b$ | $S_2/S_b$ | $S_3/S_b$ | Deflections | Strains |
| Single Axle | | | | | | | | |
| 9182 KG | 1.188 | | | 1.045 | | | 1.924 | 1.184 |
| 11127 KG | 1.314 | | | 1.105 | | | 2.825 | 1.463 |
| Tandem Axle (1.2m) | | | | | | | | |
| 13582 KG | 1.014 | 0.600 | | 0.935 | 0.934 | | 1.199 | 1.548 |
| 22327 KG | 1.403 | 0.773 | | 1.082 | 1.081 | | 3.994 | 2.696 |
| Tandem Axle (1.5m) | | | | | | | | |
| 5445 KG | 0.545 | 0.368 | | 0.641 | 0.584 | | 0.122 | 0.315 |
| 9556 KG | 0.851 | 0.604 | | 0.861 | 0.827 | | 0.688 | 1.052 |
| 10645 KG | 0.787 | 0.565 | | 0.939 | 0.935 | | 0.518 | 1.564 |
| 11718 KG | 0.907 | 0.624 | | 0.965 | 0.944 | | 0.858 | 1.748 |
| 12500 KG | 0.916 | 0.684 | | 1.049 | 0.996 | | 0.952 | 2.184 |
| 13136 KG | 0.980 | 0.722 | | 1.085 | 1.031 | | 1.214 | 2.489 |
| 13236 KG | 0.986 | 0.752 | | 1.020 | 1.002 | | 1.288 | 2.085 |
| 14582 KG | 0.979 | 0.679 | | 1.039 | 1.021 | | 1.151 | 2.237 |
| 15336 KG | 1.017 | 0.713 | | 1.079 | 1.059 | | 1.341 | 2.580 |
| 15582 KG | 1.085 | 0.722 | | 1.086 | 1.045 | | 1.655 | 2.552 |
| Tandem Axle (1.8m) | | | | | | | | |
| 14064 kg | 1.020 | 0.759 | | 0.991 | 1.014 | | 1.431 | 2.020 |
| 22127 kg | 1.313 | 0.932 | | 1.111 | 1.101 | | 3.578 | 2.937 |
| Triaxle (2.4m) | | | | | | | | |
| 20082 kg | 1.110 | 0.646 | 0.599 | 0.981 | 0.918 | 0.932 | 1.819 | 2.416 |
| 31645 kg | 1.273 | 0.722 | 0.642 | 1.089 | 1.021 | 1.069 | 2.981 | 3.753 |
| Triaxle (3.7m) | | | | | | | | |
| 20509 kg | 1.003 | 0.743 | 0.742 | 0.937 | 0.953 | 0.985 | 1.656 | 2.558 |
| 31664 kg | 1.131 | 0.887 | 0.876 | 1.114 | 1.072 | 1.081 | 2.839 | 4.152 |

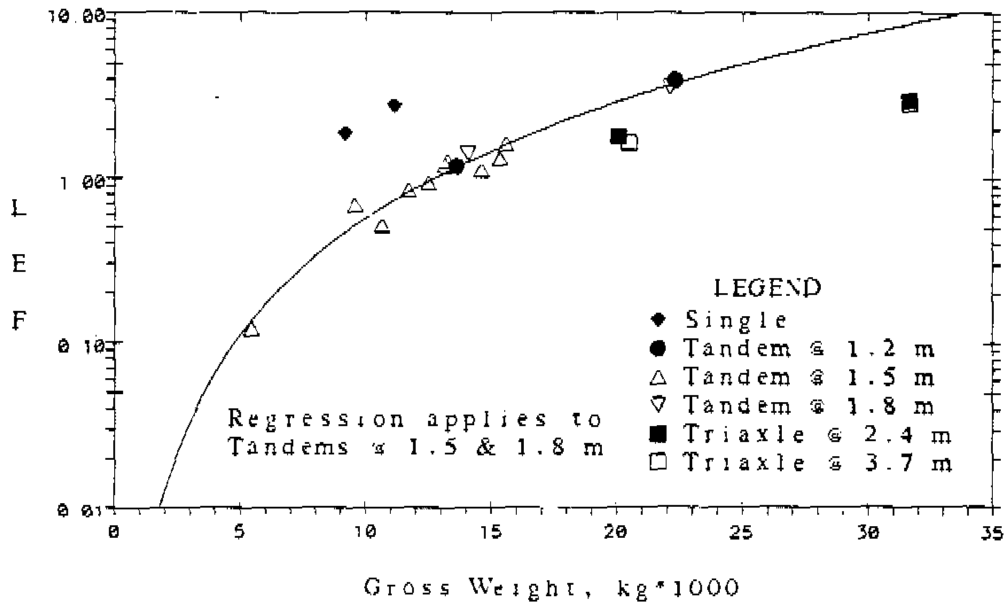


Figure4.26: Load Equivalency Factors based on Deflections: Site 13, British Columbia

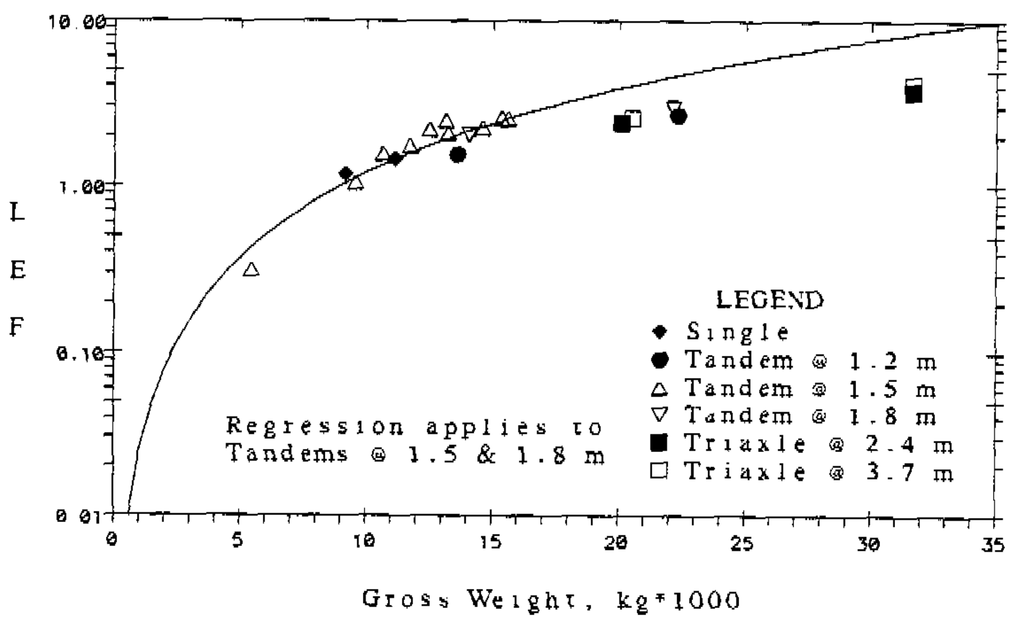


Figure4.27: Load Equivalency Factors based on Strains: Site 13, British Columbia

A. Gross Weight-Load Equivalency Factor Relationships

Tandem (1.5 - 1.8 m) Axles
Maximum Gross Weight = 22100 kg

Based on Deflections:

$F = 0.0025\ (GW)^{2.2357}$ $r^2 = 0.96$ $N = 12$ $\ell S_{ey} = 0.068$

Based on Strains:

$F = 0.0243\ (GW)^{1.693}$ $r^2 = 0.88$ $N = 12$ $\ell S_{ey} = 0.090$

where: GW = gross weight, kg x $10^3$

B. Equivalent Loadings

The following summarizes results of comparisons between equivalency factors for tandem (1.5 - 1.8 m) axle loads and equivalencies for all other axle loads and configurations tested at this site.

Note: Non-bracketed and bracketed gross weights are those obtained from comparisons of equivalency factors based on deflections and strains, respectively.

1. One application of a 12700 kg (9000 kg) tandem axle (1.5 - 1.8 m) - dual tire load is approximately equivalent in potential damaging effect to one application of the standard 8160 kg single axle-dual tire load.

2. For the range of loadings tested on carrying axle configurations of the pavement test vehicle, on average:

   One application of a tandem (1.5 - 1.8 m) load is equivalent in potential damaging effect to one application of a single axle-dual tire configuration having a gross weight equal to approximately 57 (95) percent of the tandem (1.5 - 1.8 m) load. Average gross weight equivalents for other carrying axle configurations are:

| Configuration | Percent of Tandem (1.5-1.8 m) GW |
|---|---|
| Tandem (1.2 m) | 98 (125) |
| Triaxle (2.4 m) | 140 (147) |
| Triaxle (3.7 m) | 145 (142) |

## 4.15 Equivalent Loadings and Load Applications

Combining data from all sites, overall average tandem (1.5 m to 1.8 m) axle loads equivalent in potential damaging effect to other loading conditions included in the study are presented in table 4.15. As noted in Section 3.3, the equivalent loadings were obtained from comparisons between equivalency factors for each individual loading condition and the gross weight equivalency factor relationships for tandem axle loads. The equivalent loadings indicate, for example, that based on surface deflections, one application of a 9180 kg single axle-dual tire load is, on average, equivalent in potential damaging effect to one application of a 15 900 kg tandem (1.5 m to 1.8 m) axle-dual tire load.

Table 4.15
Average Equivalent Tandem (1.5 m to 1.8 m) Axle Loads

| Loading Condition | Equivalent Tandem (1.5 m-1.8 m) Loads kgx10$^3$ | | | | | |
|---|---|---|---|---|---|---|
| | N | Based on Deflections | | N | Based on Strains | |
| Single Axle | | | | | | |
| 9180 kg | 14 | 15.9 | (1.5)* | 13 | 13.3 | (2.3) |
| 9570 kg | 6 | 17.4 | (1.4) | 6 | 13.7 | (3.1) |
| 11130 kg | 14 | 18.9 | (1.8) | 13 | 14.8 | (3.2) |
| Tandem 1.2 m | | | | | | |
| 13582 kg | 14 | 14.4 | (0.8) | 12 | 13.8 | (1.7) |
| 18100 kg | 10 | 18.4 | (2.2) | 9 | 16.8 | (1.3) |
| 22327 kg | 14 | 23.1 | (2.5) | 12 | 18.3 | (2.2) |
| Triaxle 2.4 m | | | | | | |
| 20082 kg | 14 | 15.3 | (1.8) | 12 | 14.6 | (1.6) |
| 26145 kg | 10 | 17.6 | (1.5) | 9 | 18.7 | (1.6) |
| 31645 kg | 14 | 22.1 | (2.4) | 12 | 21.1 | (1.9) |
| Triaxle 3.7 m | | | | | | |
| 20510 kg | 14 | 14.8 | (2.0) | 12 | 16.2 | (1.6) |
| 26036 kg | 10 | 17.6 | (1.8) | 9 | 18.9 | (1.6) |
| 31664 kg | 14 | 21.2 | (1.5) | 12 | 21.2 | (2.1) |
| Triaxle 4.9 m | | | | | | |
| 25836 kg | 6 | 18.5 | (2.2) | 6 | 20.2 | (1.3) |
| 31955 kg | 6 | 24.2 | (2.2) | 6 | 22.9 | (0.7) |

*One standard deviation
N-Number of comparisons

The average equivalent tandem axle loads are approximately a constant multiple of the loads on each configuration. For example, based on pavement surface deflections, average tandem (1.5 m to 1.8 m) axle-dual tire loads equivalent in potential damaging effect to single axle-dual tire loads are 1.73, 1.82 and 1.70 (15.9/9.18, 17.4/9.57 and 18.9/11.13) times the magnitude of the single axle loads. Combining the equivalent loadings by axle configuration, average equivalent tandem axle load ratios (K) for each configuration are:

| Axle Configuration | Based on Deflections | | | Based on Strains | | |
|---|---|---|---|---|---|---|
| | N | K | $\sigma$ | N | K | $\sigma$ |
| Single Axle | 34 | 1.73 | 0.17 | 32 | 1.34 | 0.26 |
| Tandem 1.2 m | 38 | 1.04 | 0.10 | 33 | 0.92 | 0.13 |
| Triaxle 2.4 m | 38 | 0.72 | 0.08 | 33 | 0.70 | 0.07 |
| Triaxle 3.7 m | 38 | 0.69 | 0.08 | 33 | 0.73 | 0.09 |
| Triaxle 4.9 m | 12 | 0.73 | 0.08 | 12 | 0.75 | 0.05 |

The average deflection related load ratios indicate that:

i) For the range of single axle-dual tire loads included in the study, the magnitude of the average equivalent tandem (1.5 m to 1.8 m) axle load is 1.73 times the magnitude of the single axle load. Conversely, for a given tandem load the magnitude of the equivalent single axle load is approximately 58 percent (1/1.73) of the tandem load. This percent is in close agreement with 60 percent established from previous analyses of deflections and strains recorded under single and tandem axles having gross weights ranging from 5700 to 12 000 kg and from 9700 to 20 000 kg, respectively, (Ref.1) and with the AASHO performance related load equivalency factors (Ref.5).

ii) For a given tandem (1.2 m) axle-dual tire gross weight, the magnitude of the equivalent tandem (1.5 m to 1.8 m) axle load is, on average, 104 percent of the tandem (1.2 m) axle load. This finding indicates that, at comparable load magnitudes, increasing the centre to centre spacing between axles from 1.2 to 1.5 m decreases the relative potential damaging effect of tandem axles.

iii) On average, for a given tandem (1.5 to 1.8 m) axle-dual tire load, equivalent triaxle (2.4 m) and (3.7 m) loads are approximately 1.39 (1/0.71) and 1.45 (1/0.69) times, respectively, the magnitude of the tandem load. At comparable gross weights, increasing the centre to centre spacing between adjacent axles of a triaxle from 1.2 m to 1.85 m decreases the relative potential damaging effect of the axle group. The average equivalent gross weight ratios are in close agreement with the value of 1.4 obtained from results of previous field studies carried out to assess the relative destructive effects of tandem and triaxle configurations (Ref.1).

iv) Relative to a triaxle (3.7 m)-dual tire load, the equivalent gross weight of a belly-tandem axle group having a centre to centre spacing between the belly and lead tandem axle equal to 3.0 m (the triaxle 4.9 m configuration) is approximately 95 percent (0.69/0.73) of the conventional triaxle load.

With the exception of the single axle-dual tire configuration, average equivalent load ratios obtained from comparisons between predicted equivalency factors based on asphaltic concrete fatigue life-tensile strain criteria are in close agreement with those derived from deflection measurements. Reasons for the relatively low tandem/single load ratio value (1.34) have not been identified. However, an examination of the data indicated that below average ratio values were generally associated with test sites where changes in recorded strains with variations in gross axle weight were small. These sites were 4, 5, 6, 12 and 13. Deleting these sites from the analysis, the average equivalent tandem/single load ratio was found to equal 1.55.

The average strain related load ratios reveal that for a given tandem (1.2 m) axle load the equivalent tandem (1.5 m to 1.8 m) axle is, on average, 92 percent of the tandem (1.2 m) load. Similarily an equivalent triaxle (3.7 m) load is approximately 96 percent (0.70/0.73) of a triaxle (2.4 m) load. These comparisons indicate that increasing the centre to centre spacing between axles increases the relative potential damaging effect of the axle group. This finding is contrary to the results obtained from comparisons of the deflection based load ratios; suggesting that, for the range of axle spacing included in the study (1.2 m to 1.8 m), the influence of variations of axle spacing on potential pavement damage is dependent on the postulated, deflection or strain related, pavement distress criteria. Use of the average ratios to identify equivalent configuration gross weights beyond the limits of the loadings included in the test program is cautioned.

Relative destructive effects, expressed in terms of equivalent number of load applications, of various axle configurations at comparable gross weights are summarized below. Utilizing data from all sites, the equivalent load applications equal the overall average of individual comparisons between predicted load equivalency factors for the noted loading conditions. The non-bracketed and bracketed average equivalent load applications, together with the standard deviations $\sigma$ and number of individual comparisons N, are those obtained from comparisons of the deflection and strain related equivalency factors, respectively.

i) At comparable gross weights (9200, 9600 and 11 100 kg), one application of a single axle-dual tire is equivalent in potential damaging effect to 4.4 (3.2) applications of a tandem (1.5 m to 1.8 m) axle configuration.

$\sigma$ = 1.2 (1.6), N = 34 (21)

ii) One application of a 20 000 kg tandem (1.5 m to 1.8 m) axle-dual tire load is equivalent in destructive effect as 2.1 (2.2) applications of a triaxle (2.4 m) configuration, and as 2.6 (1.8) applications of a triaxle (3.7 m) configuration, having the same gross weight.

$\sigma$ = 0.6 (0.9), N = 14 (13) for the triaxle (2.4 m)
$\sigma$ = 1.0 (0.7), N = 14 (13) for the triaxle (3.7 m)

iii) At comparable gross weights (13 600, 18 100 and 22 300 kg), one application of a tandem (1.2 m) axle-dual tire is equivalent in potential damaging effect to 1.2 (0.9) applications of a tandem (1.5 m to 1.8 m) axle.

$\sigma$ = 0.3 (0.3), N = 38 (33)

iv) At comparable load magnitudes (25 800 and 32 000 kg), one application of a belly-tandem axle grouping, the triaxle (4.9 m) configuration, is equivalent in destructive effect as 1.2 (1.1) applications of a triaxle (3.7 m)-dual tire.

$\sigma$ = 0.2 (0.1), N = 12 (12)

v) For gross weights ranging from 20 000 to 32 000 kg, one application of a triaxle (2.4 m) axle-dual tire is equivalent in potential damaging effect to 1.2 (0.9) applications of a triaxle (3.7 m) axle-dual tire.

$\sigma$ = 0.4 (0.2), N = 38 (33)

# 5.0 INFLUENCE OF STRUCTURE ON PREDICTED LOAD EQUIVALENCY FACTORS

The following presents results of analyses carried out to assess the effects of pavement structure on the magnitude of the predicted load equivalency factors. The analyses were conducted using the gross weight-equivalency factor relationships developed for tandem (1.5 m to 1.8 m) axle loads. A brief description of each instrumented pavement structure is presented in table 5.1.

## 5.1 Deflection Related Equivalency Factors

The gross weight versus load equivalency factor relationships derived from deflections recorded under the tandem (1.5 m and 1.8 m) axle configurations are shown in figure 5.1. The predicted factors are highly dependent on the magnitude of the relative deflection ratio $D_1/D_b$. Based on the assumed pavement distress criteria and selected exponent coefficient of 3.8 (Section 2.1), a 10 percent variation in $D_1/D_b$ results in approximately a 40 percent change in the magnitude of the predicted equivalencies. From figure 5.1, maximum predicted factors, site 3A, were approximately twice the magnitude of those for site 8. This extreme site to site difference reflects a 20 percent difference between the magnitude of average deflection ratios for the two sites. Excluding site 8, average deflection ratios for a given load at any one site were within ±7 percent of the mean ratios for all sites. Compared to differences in component layer thicknesses and materials comprising the various structures, these site to site variations in relative response measurements are small. The old road bed subbase at site 8 appears to be the main structural component difference between this and other sites.

Using an asphalt concrete/base/subbase equivalent layer thickness ratio equal to 2:1:0.5, an equivalent base layer thickness was calculated for each structure. A plot of equivalent base layer thicknesses versus predicted equivalency factors for 10 000 kg and 20 000 kg tandem axle loads is shown in figure 5.2. The predicted factors show no measurable trend with changes in equivalent base thickness.

Table 5.1 Pavement Test Sites

| Site No. | Province | Location | Structure | | | |
|---|---|---|---|---|---|---|
| | | | A.C. Thick.(mm) | Base Thick.(mm)-Material | Sub-Base Thick.(mm)-Material | Subgrade Material |
| 1 | New Brunswick | Hwy.15 - 10 km. E. of Moncton | 225 | 76 - Crushed rock | 460 - Crushed sandstone | Silty-sand |
| 2 | Nova Scotia | Hwy.102 - 6 km. S. of Truro | 160 | 275 - Granular | 200 - Granular | Gravelly-clay |
| 3A | Quebec | Hwy.40 - 55 km. W. of Quebec City | 135 | 200 - Crushed limestone | 625 - Granite sand | Granitic-gravel |
| 3B | Quebec | Hwy.40 - 55 km. W. of Quebec City | 130 | 375 - Crushed limestone | 450 - Granitic sand | Granitic-gravel |
| 4 | Quebec | Rte.363 - 73 km. W. of Quebec City | 56 | 150 - Granitic gneiss | 450 - Granitic sand | Clay |
| 5 | Quebec | Rte.363 - 73 km. W. of Quebec City | 56 | 200 - Granitic gneiss | 550 - Granitic sand | Clay |
| 6 | Ontario | Hwy.7-Peterborough Bypass | 110 | 150 - Granular A | 350 - Granular C | Silty-sand |
| 7 | Ontario | Hwy.403 - 19 km. W. of Brantford | 170 | 200 - Granular A | 250 - Granular B | Sand |
| 8 | Ontario | Hwy.55 - 8 km. E. of St. Catharines | 190 | 300 - Granular A | 90 - Old road | Clay |
| 9 | Alberta | Hwy.21 - 8 km. N. of Three Hills | 136 | 170 - Cement Stab. Sand | - - | Clay |
| 10 | Alberta | Hwy.21 - 8 km. N. of Three Hills | 136 | 250 - Granular | - - | Clay |
| 11 | British Columbia | Hwy.97 - 110 km. W. of Chetwynd | 75 | 145-Asphalt bnd.gran.<br>200 - Granular | 610 - Granular<br>1000 - Shot rock | Peat/Silty Sand |
| 12 | British Columbia | Hwy.97 - 112 km. W. of Chetwynd | 85 | 155-Asphalt bnd.gran.<br>210 - Granular | 610 - Granular<br>975 - Silty gravel | Silty-sand |
| 13 | British Columbia | Hwy.16 - 16 km. N.W. of Tete Jaune Cache | 100 | 545 - Granular | 50 - Clay and sand<br>450 - Pit run gravel | Clay |

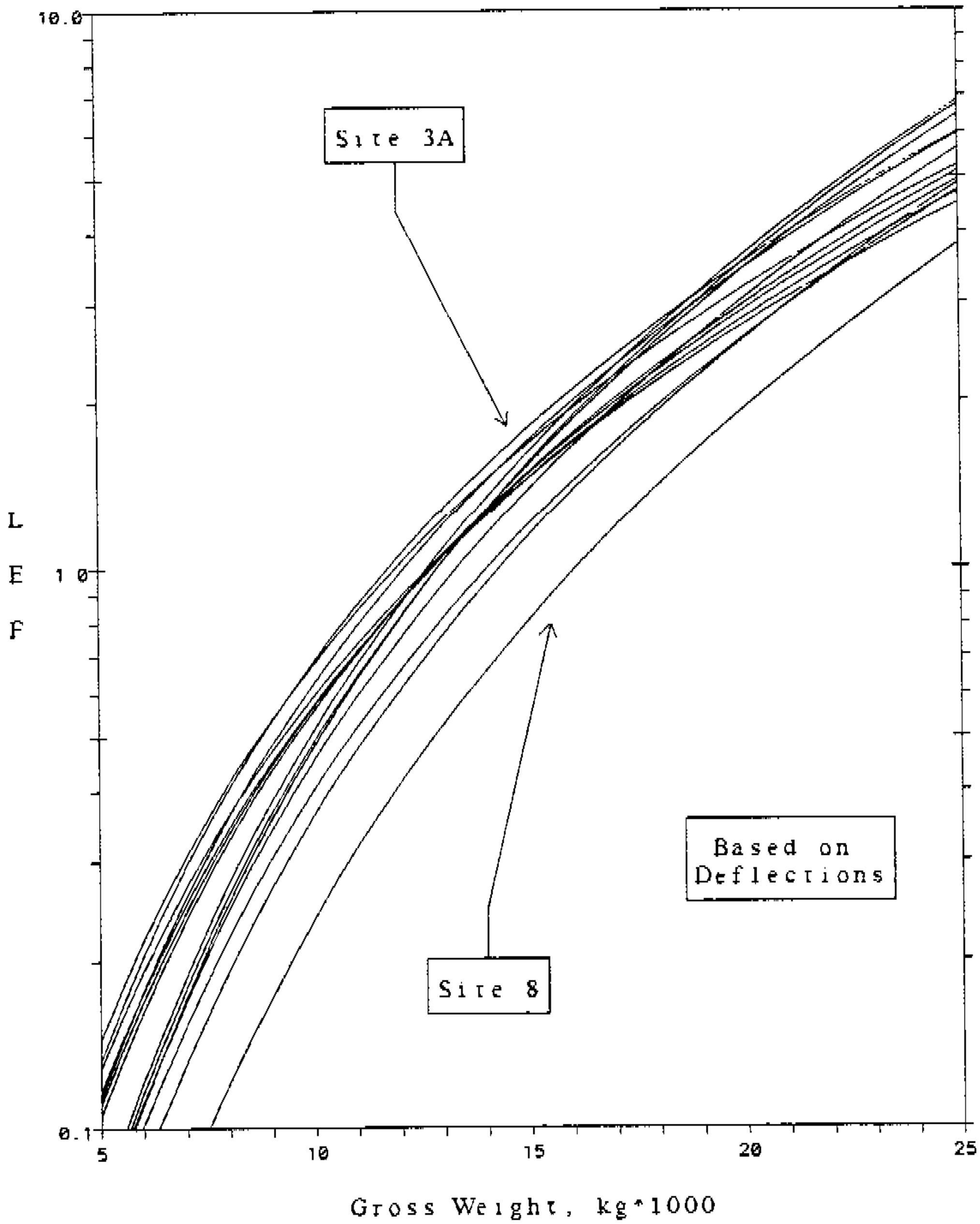


Figure 5.1: Gross Weight-Load Equivalency Factor Relationships for Tandem (1.5-1.8 m) Axles for all Test Sites

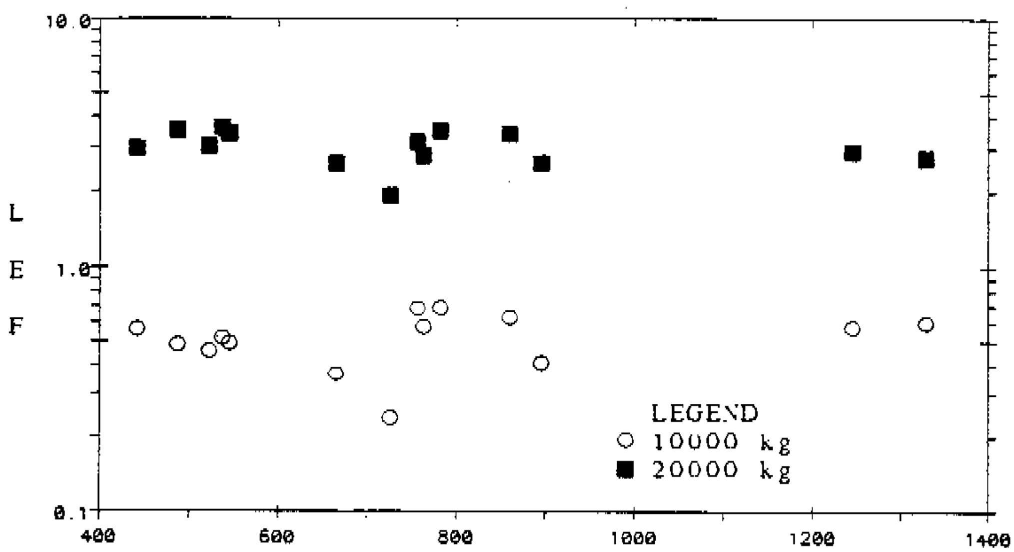


Figure 5.2: Influence of Equivalent Base Thickness on Predicted Load Equivalency Factors

## 5.2 Strain Related Equivalency Factors

Gross weight-load equivalency factor relationships derived from tensile strains recorded under tandem (1.5 m and 1.8 m) axle configurations at each site are presented in figure 5.3. At a gross weight equal to 10 000 kg the equivalencies ranged from approximately 0.3 to 2.0, at 15 000 kg from 1.0 to 4.0, and at 20 000 kg from approximately 2.0 to 7.0. That is, site to site variations in the magnitude of the predicted equivalencies tended to decrease with increasing load.

An examination of the average axle weight-strain ratio relationships for leading axles of tandem and triaxle configurations, presented in the Appendix, indicated that the magnitude of the strain ratios tended to decrease with increasing asphalt concrete thickness. From this observation, predicted equivalencies for tandem gross weights equal

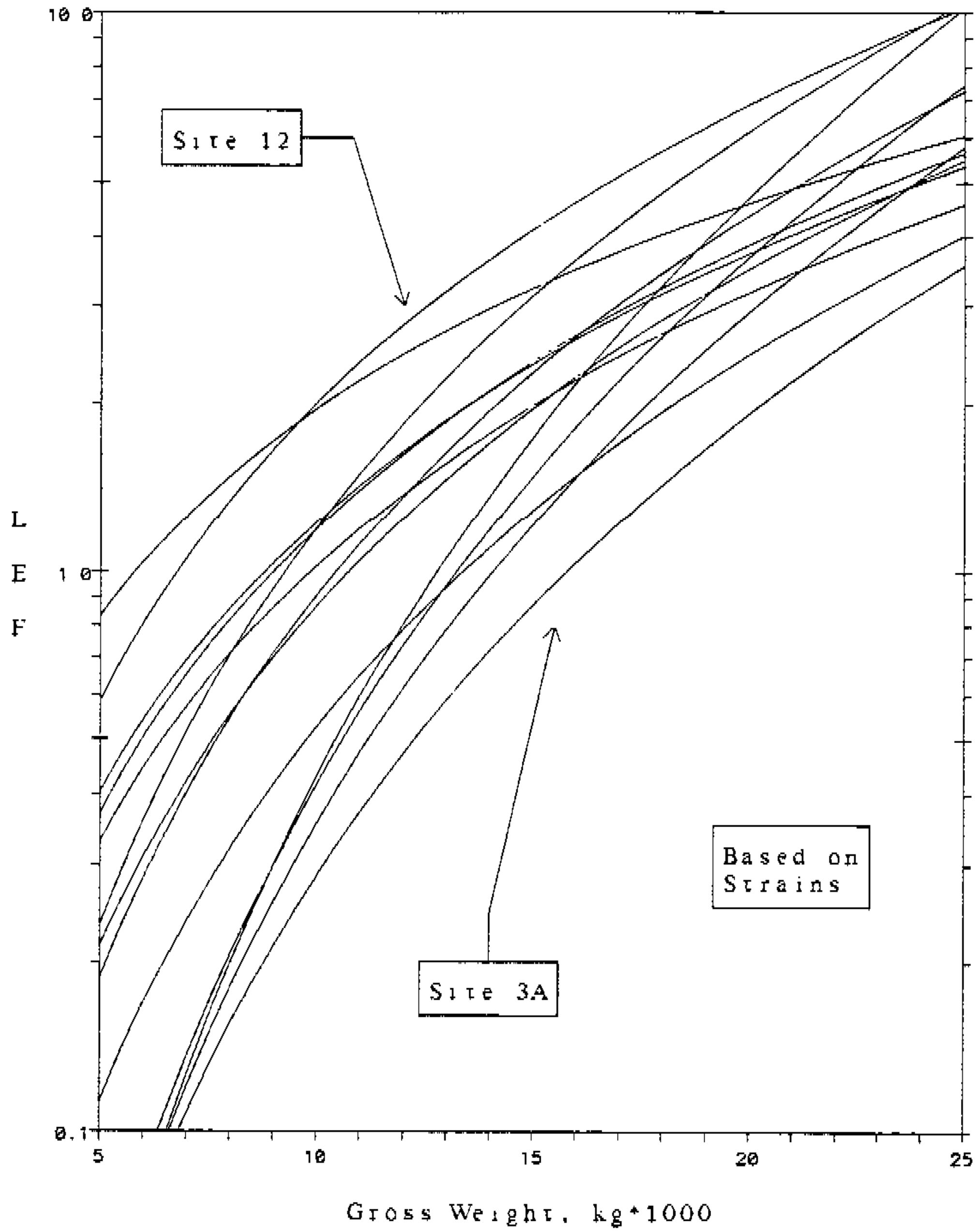


Figure 5.3: Gross Weight-Load Equivalency Factor Relationships for Tandem (1.5-1.8 m) Axles for all Test Sites

to 10 000 kg and 20 000 kg at each site are shown as a function of asphalt concrete thickness in figure 5.4. These plots reveal that, at the lighter load, equivalency factors decreased as asphalt concrete thickness increased from approximately 85 mm to 190 mm and, thereafter, remained relatively constant with increasing asphalt concrete thickness. At the heavier load, and based on limited test results, the factors were less sensitive to variations in pavement surface thickness. (A maximum of two tests/site were carried out at this load level.)

Combining test site data, regression analyses relating the predicted tandem (1.5 m and 1.8 m) equivalency factors to gross weight (GW,kg) and asphalt concrete thickness (T,mm) yielded the expression:

$$\log_{10} (F) = 0.578 + 0.0155\,(T)\,(\log_{10} GW) - 0.0669(T)$$

$$r^2 = 0.86 \qquad 1Sey = 0.144 \quad N = 204$$

Using this expression, equivalencies for an 16 000 kg tandem axle load (approximating present maximum allowable loadings) increase from approximately 1.8 to 2.6 as asphalt concrete thickness decreases from 200 mm to 100 mm. That is, based on asphalt concrete fatigue life-tensile strain criteria, one application of an 16 000 kg tandem axle load on the thinner pavement is equivalent in potential damaging effect as 1.4 (2.6/1.8) applications of the same load on the thicker pavement. Similarly, the equivalent load application ratio (F,100mm/F,200mm) for an 10 000 kg tandem axle load equals 3.0(1.2/0.4). (Due to the limited number of tests conducted at heavier loadings, use of the above expression for estimating load factors for tandem (1.5 m - 1.8 m) axles exceeding 16 000 kg is cautioned.)

The results of the above analyses reveal that the site to site variations in load equivalency factors predicted from the in situ tensile strain measurements can be attributed, in part, to variations in asphalt concrete thicknesses. The equivalency-asphalt thickness dependency lends support to load equivalency factors for fatigue cracking developed using mechanistic pavement models (Ref. 7).

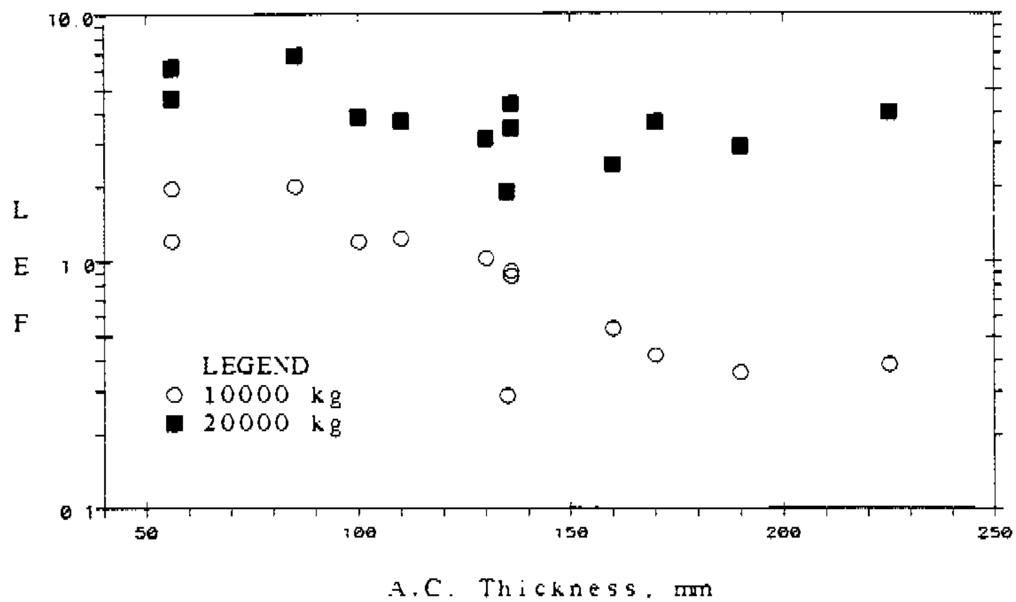


Figure 5.4: Influence of A.C. Thickness on Predicted Load Equivalency Factors

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# APPENDIX

## AXLE WEIGHT-PAVEMENT RESPONSE RELATIONSHIPS

**Table A1**
**Axle Weight - Pavement Response Relationships**

Pavement Response Ratio = K $(AW)^C$
Where: AW = Axle Weight; kg x $10^3$

| Site No. | Deflection Ratio $D_1/D_b$ (Axles @ 1.5 & 1.8 m Spacing) | | | | | Strain Ratio $S_1/S_b$ (Axles @ 1.2, 1.5 & 1.8 m Spacing) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | K | C | N | $r^2$ | $\ell S_{ey}$ | K | C | N | $r^2$ | $\ell S_{ey}$ |
| 1 | 0.299 | 0.624 | 23 | 0.94 | 0.023 | 0.153 | 0.886 | 29 | 0.98 | 0.020 |
| 2 | 0.311 | 0.546 | 20 | 0.78 | 0.037 | 0.309 | 0.525 | 26 | 0.91 | 0.022 |
| 3A | 0.280 | 0.672 | 23 | 0.98 | 0.014 | 0.175 | 0.764 | 29 | 0.93 | 0.030 |
| 3B | 0.274 | 0.670 | 23 | 0.98 | 0.014 | 0.419 | 0.431 | 29 | 0.87 | 0.024 |
| 4 | 0.226 | 0.787 | 20 | 0.99 | 0.008 | 0.814 | 0.157 | 26 | 0.34 | 0.028 |
| 5 | 0.242 | 0.747 | 20 | 0.98 | 0.012 | 0.515 | 0.377 | 26 | 0.49 | 0.049 |
| 6 | 0.231 | 0.741 | 23 | 0.95 | 0.023 | 0.498 | 0.365 | 29 | 0.78 | 0.023 |
| 7 | 0.220 | 0.745 | 14 | 0.97 | 0.017 | 0.189 | 0.775 | 18 | 0.94 | 0.028 |
| 8 | 0.180 | 0.803 | 14 | 0.98 | 0.015 | 0.178 | 0.781 | 18 | 0.99 | 0.012 |
| 9 | 0.271 | 0.698 | 23 | 0.96 | 0.021 | 0.354 | 0.529 | 29 | 0.94 | 0.019 |
| 10 | 0.226 | 0.768 | 23 | 0.98 | 0.017 | 0.314 | 0.593 | 29 | 0.94 | 0.021 |
| 11 | 0.217 | 0.763 | 14 | 0.98 | 0.013 | | | | | |
| 12 | 0.268 | 0.649 | 20 | 0.84 | 0.036 | 0.536 | 0.389 | 24 | 0.66 | 0.030 |
| 13 | 0.296 | 0.624 | 14 | 0.94 | 0.021 | 0.443 | 0.426 | 17 | 0.86 | 0.022 |

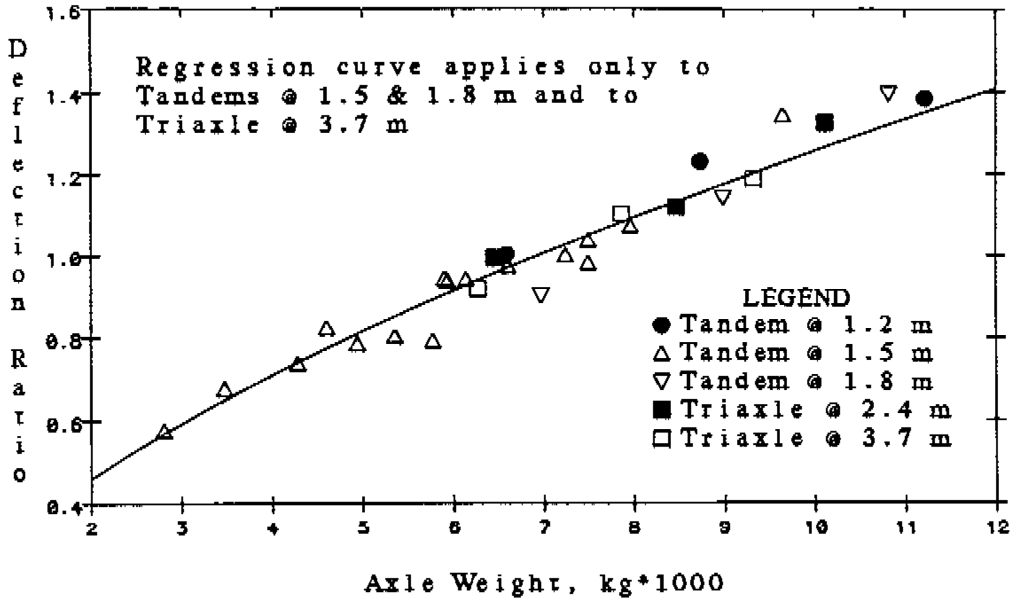


Figure A1: Deflection Ratios for Lead Axle
Site 1, New Brunswick

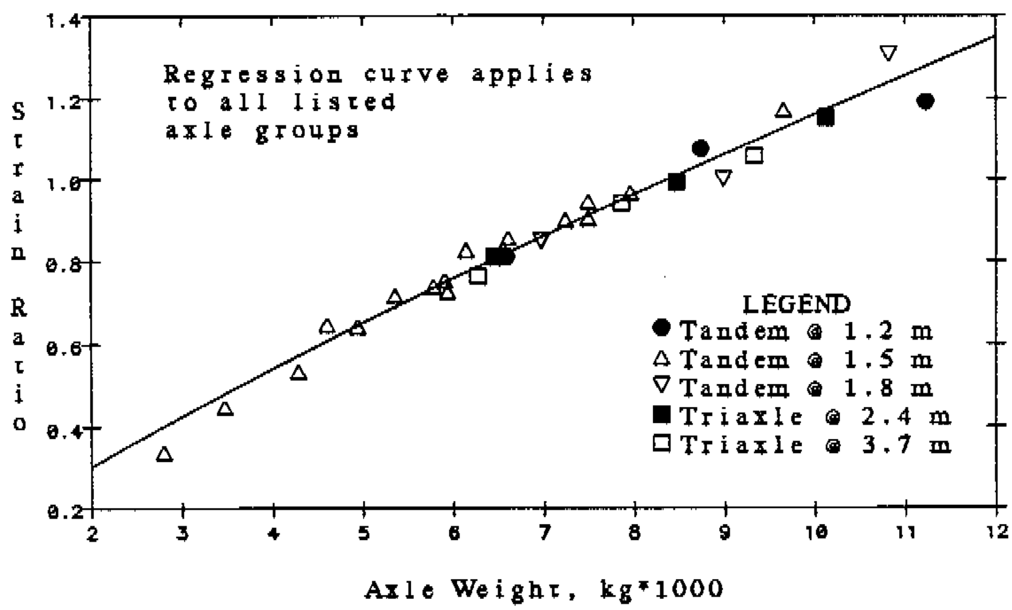


Figure A2: Strain Ratios for Lead Axle
Site 1, New Brunswick

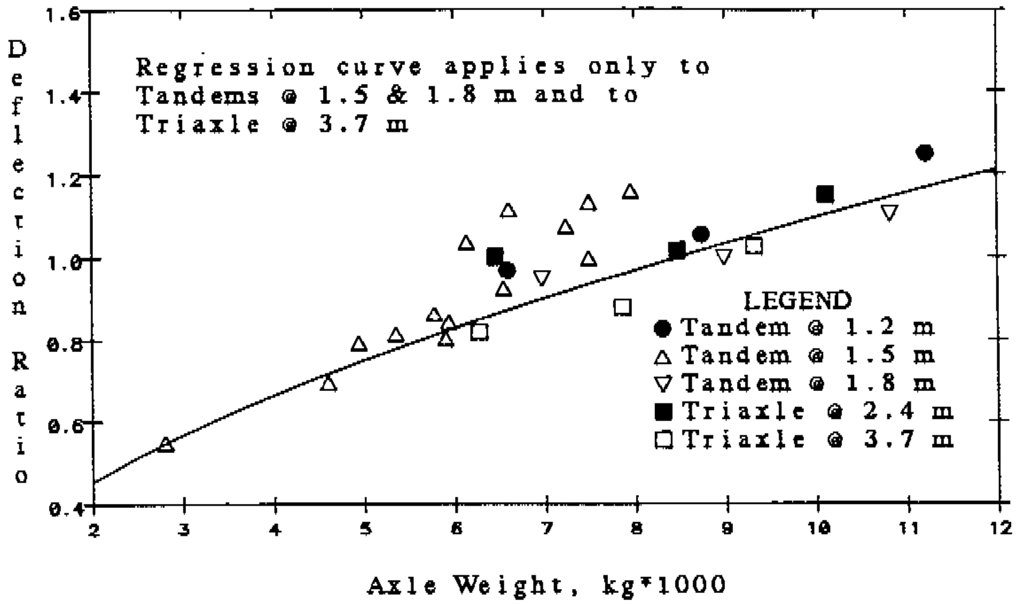


Figure A3: Deflection Ratios for Lead Axle
Site 2, Nova Scotia

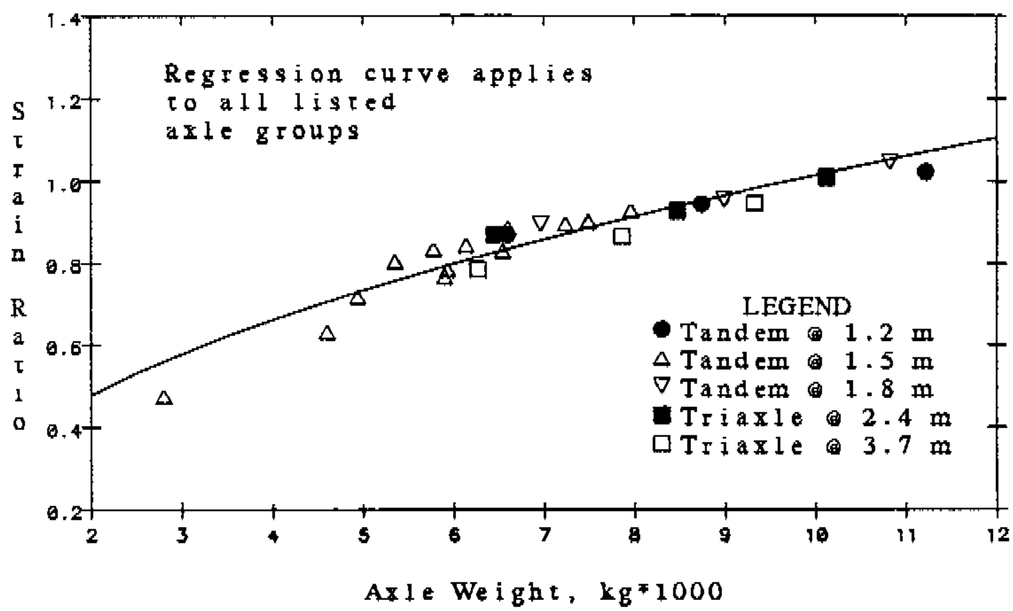


Figure A4: Strain Ratios for Lead Axle
Site 2, Nova Scotia

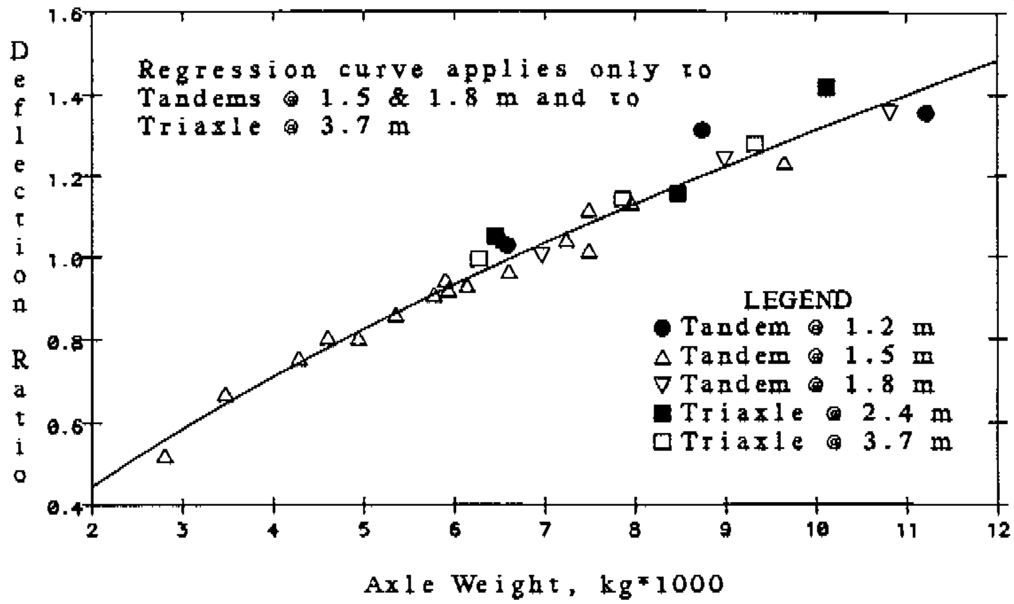


Figure A5: Deflection Ratios for Lead Axle
Site 3A, Quebec

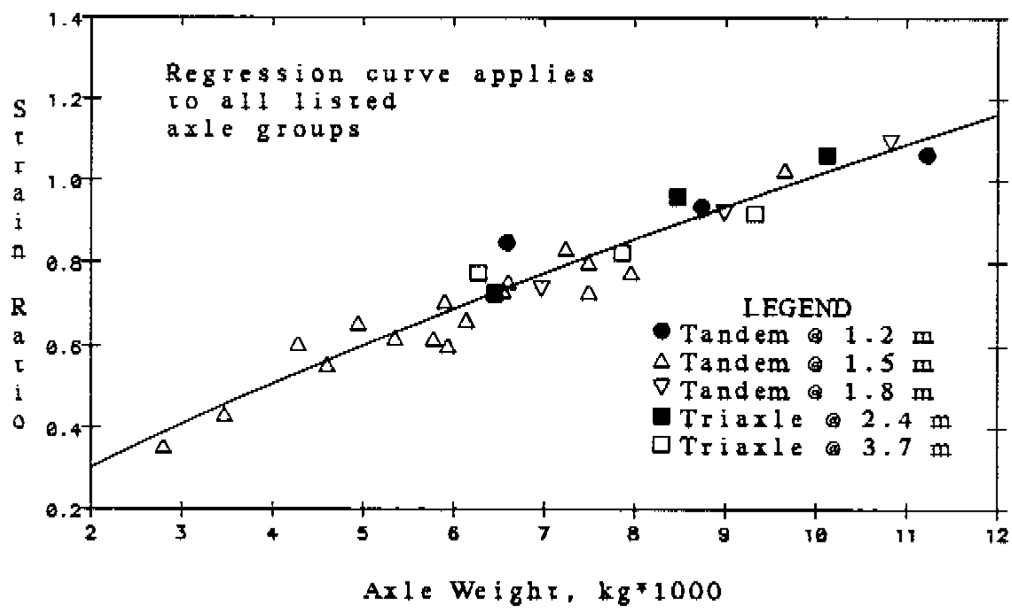


Figure A6: Strain Ratios for Lead Axle
Site 3A, Quebec

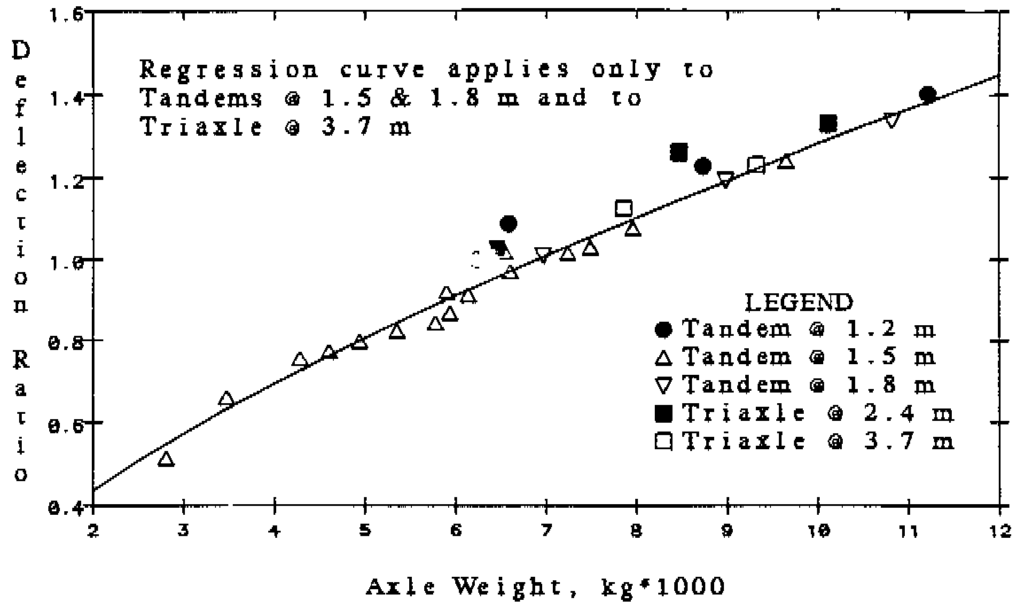


Figure A7: Deflection Ratios for Lead Axle
Site 3B, Quebec

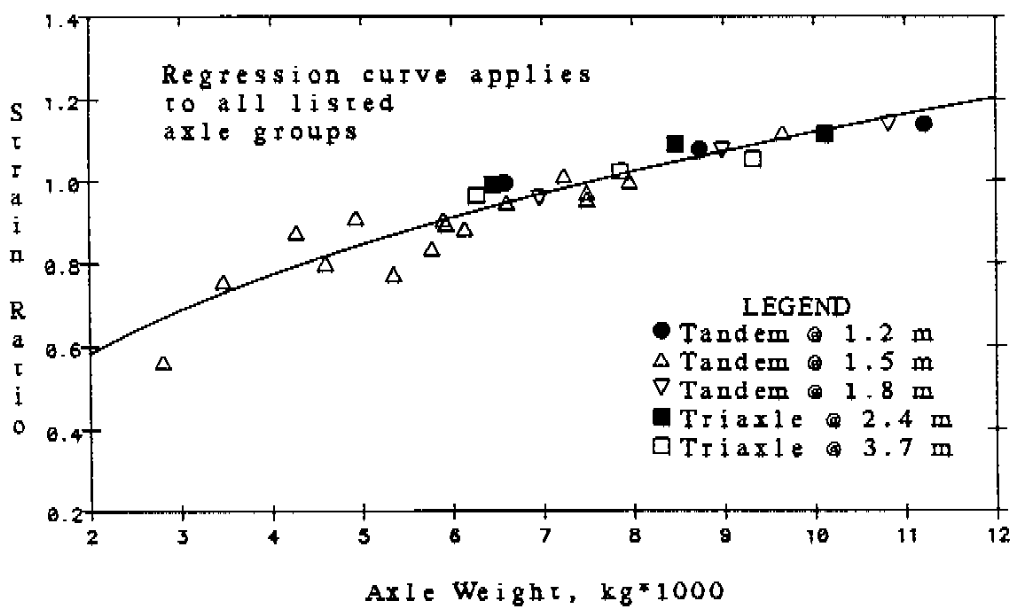


Figure A8: Strain Ratios for Lead Axle
Site 3B, Quebec

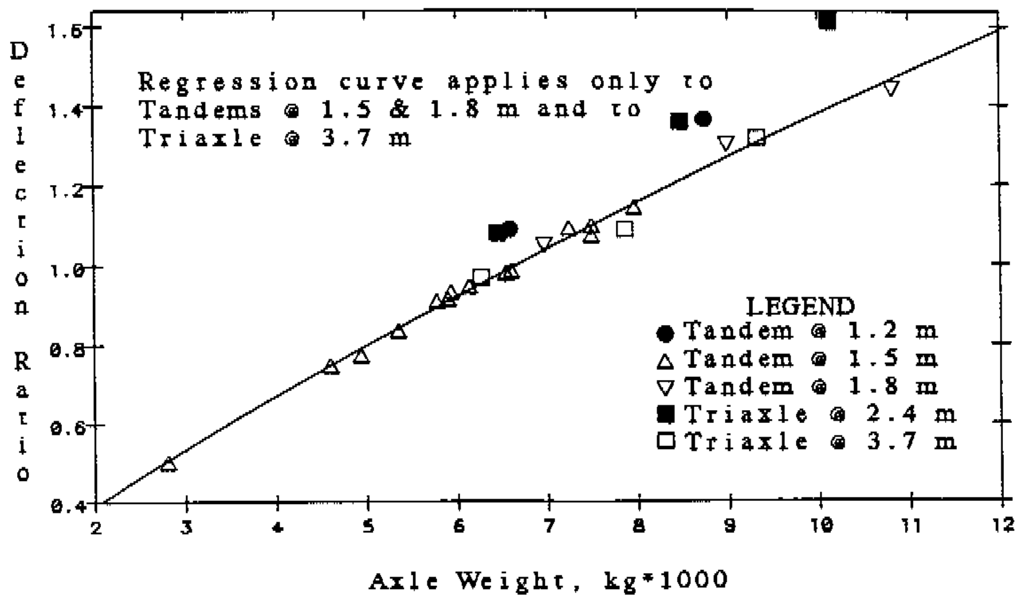


Figure A9: Deflection Ratios for Lead Axle
Site 4, Quebec

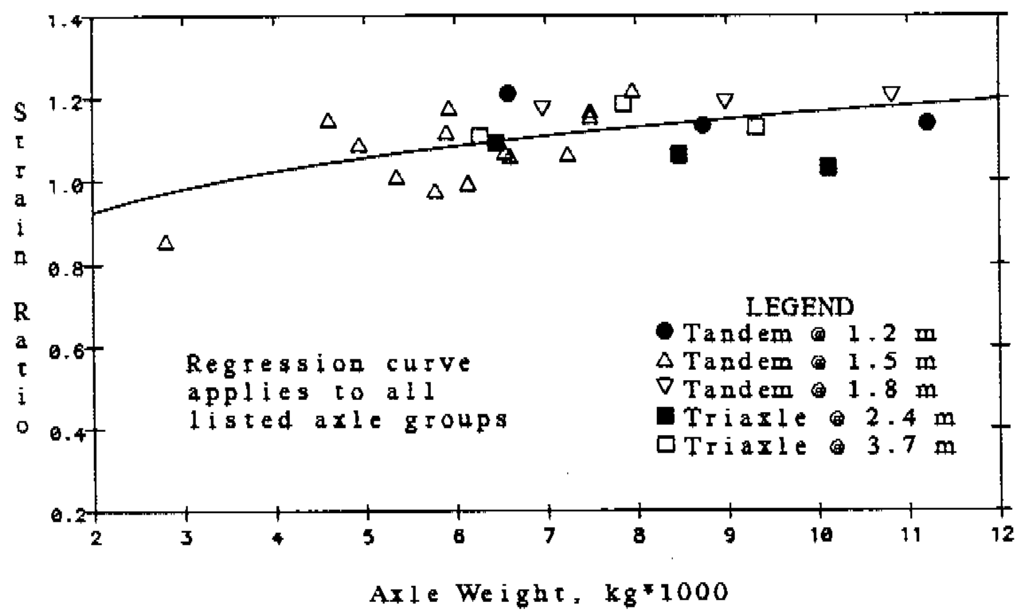


Figure A10: Strain Ratios for Lead Axle
Site 4, Quebec

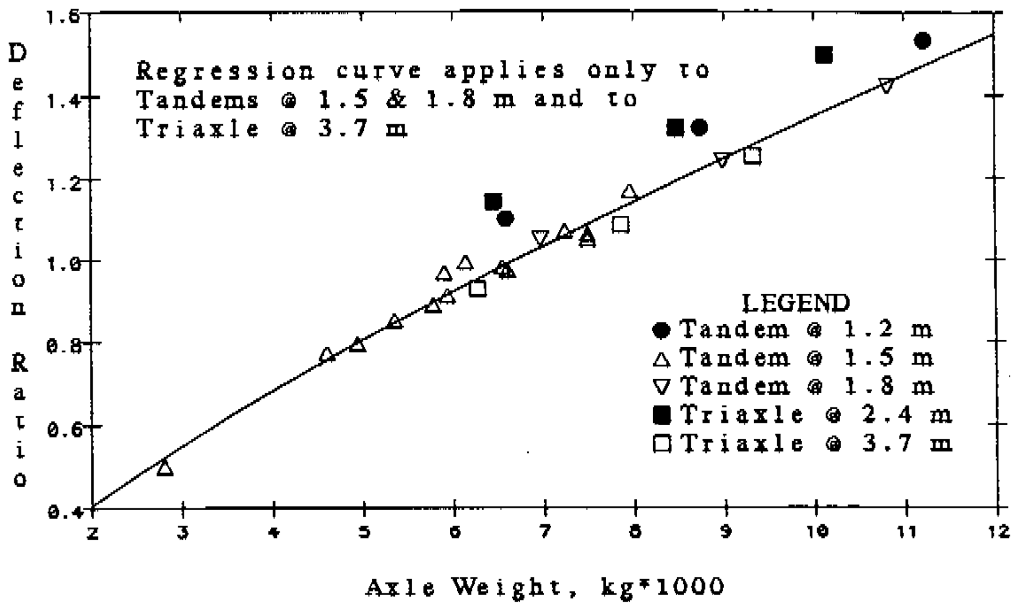


Figure A11: Deflection Ratios for Lead Axle
Site 5, Quebec

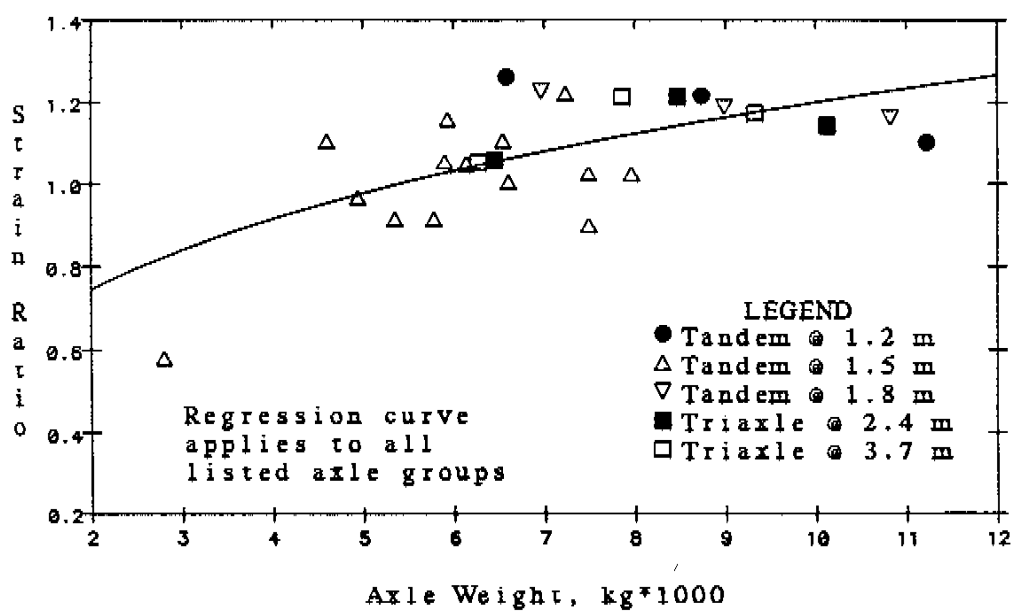


Figure A12: Strain Ratios for Lead Axle
Site 5, Quebec

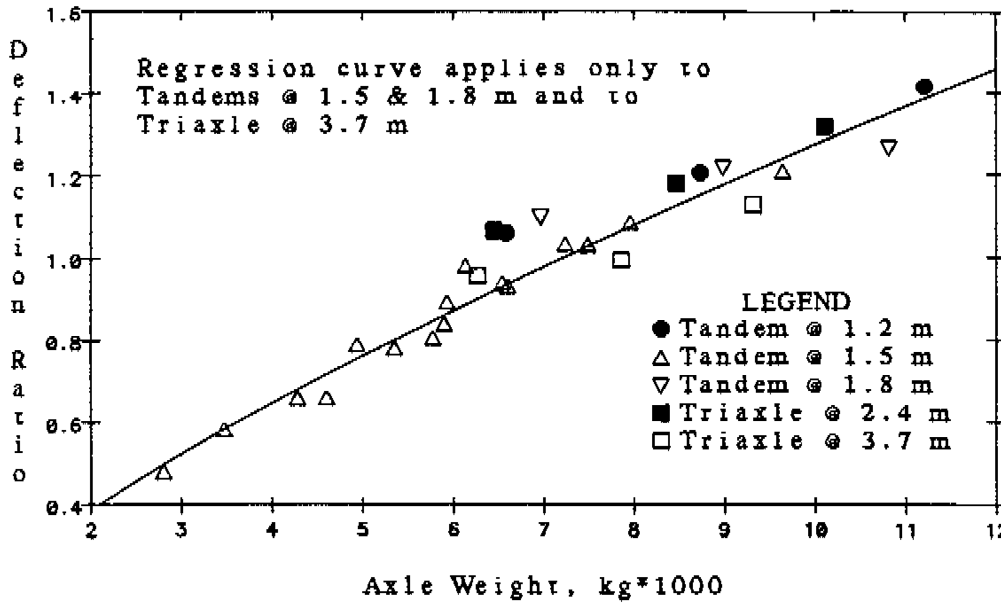


Figure A13: Deflection Ratios for Lead Axle
Site 6, Ontario

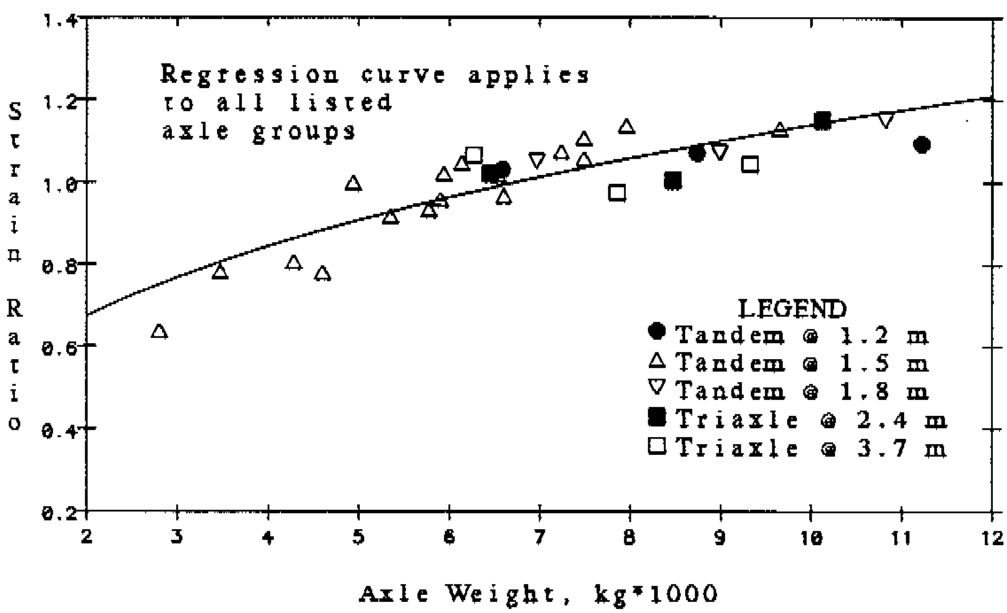


Figure A14: Strain Ratios for Lead Axle
Site 6, Ontario

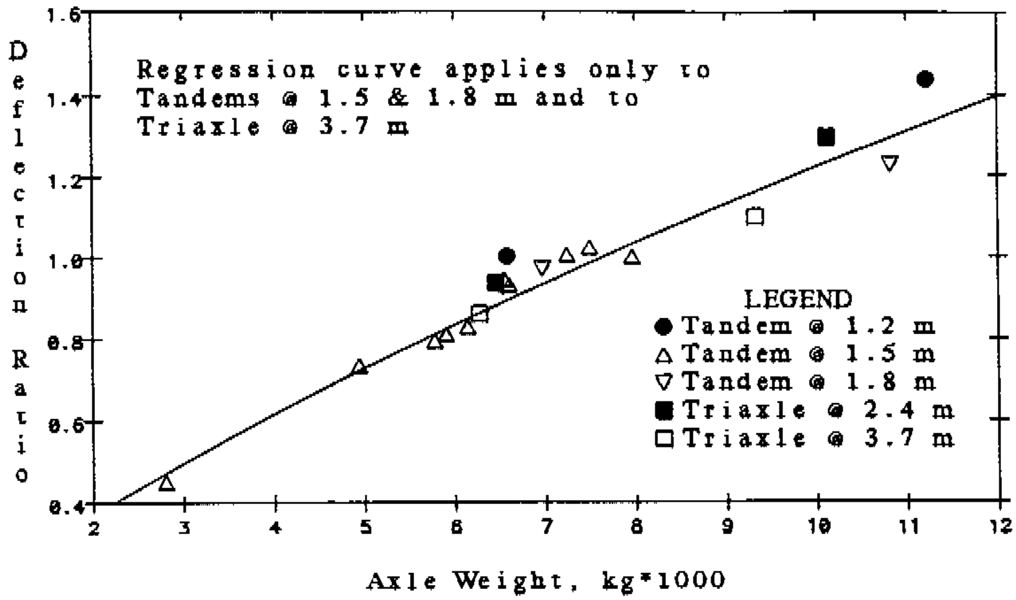


Figure A15: Deflection Ratios for Lead Axle
Site 7, Ontario

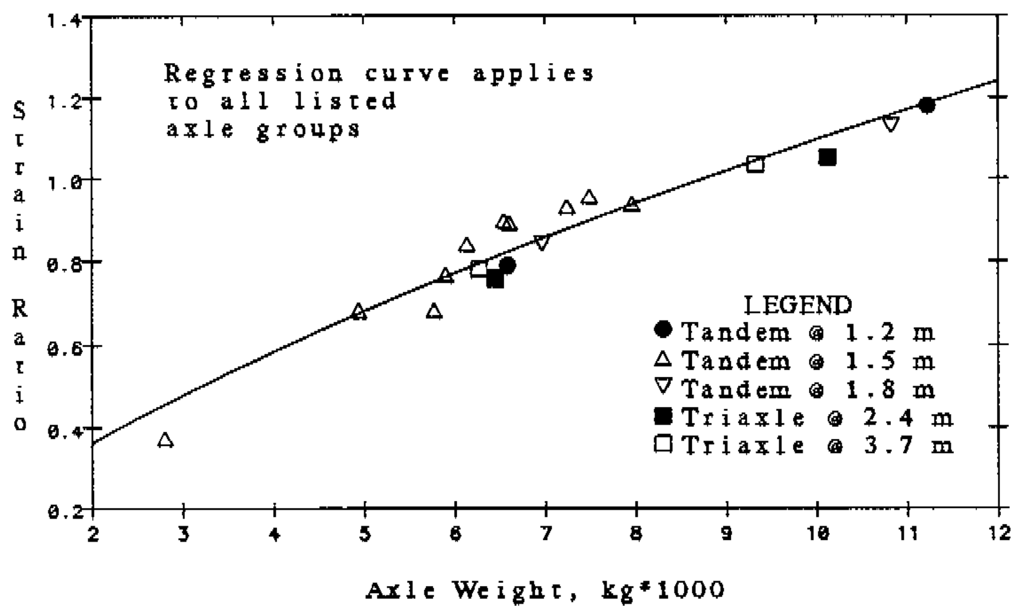


Figure A16: Strain Ratios for Lead Axle
Site 7, Ontario

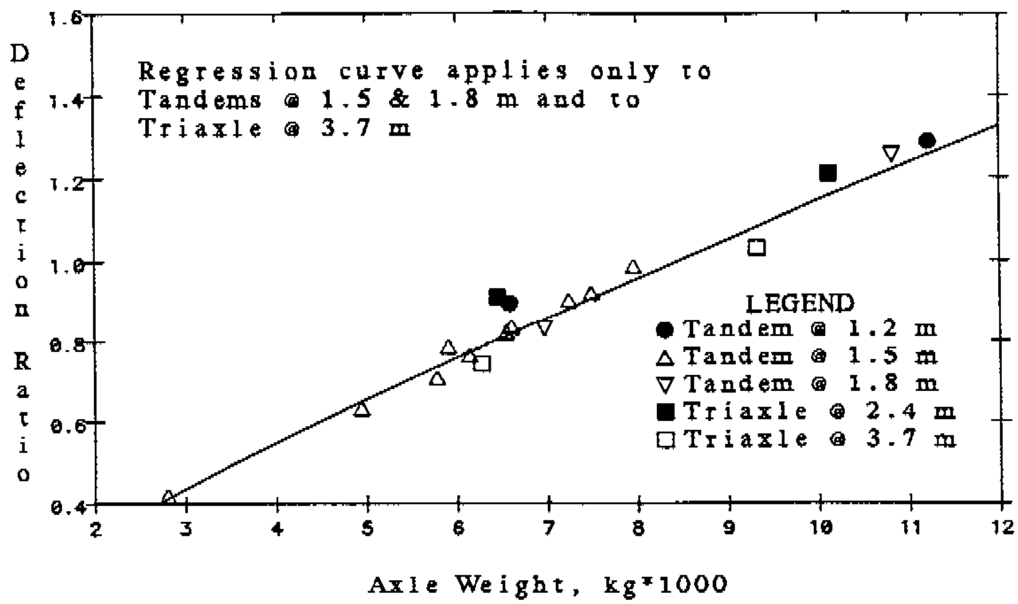


Figure A17: Deflection Ratios for Lead Axle
Site 8, Ontario

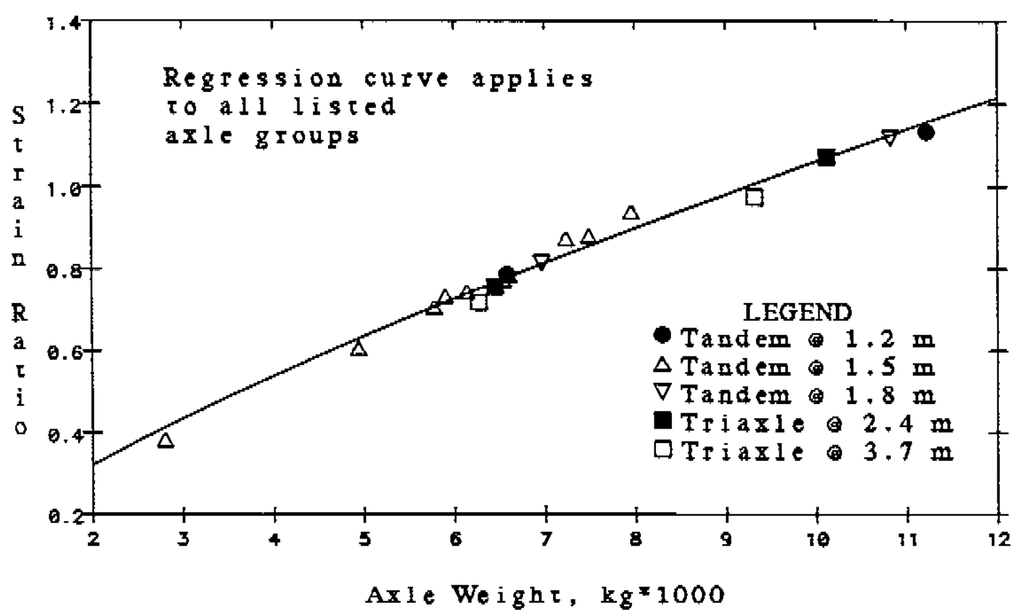


Figure A18: Strain Ratios for Lead Axle
Site 8, Ontario

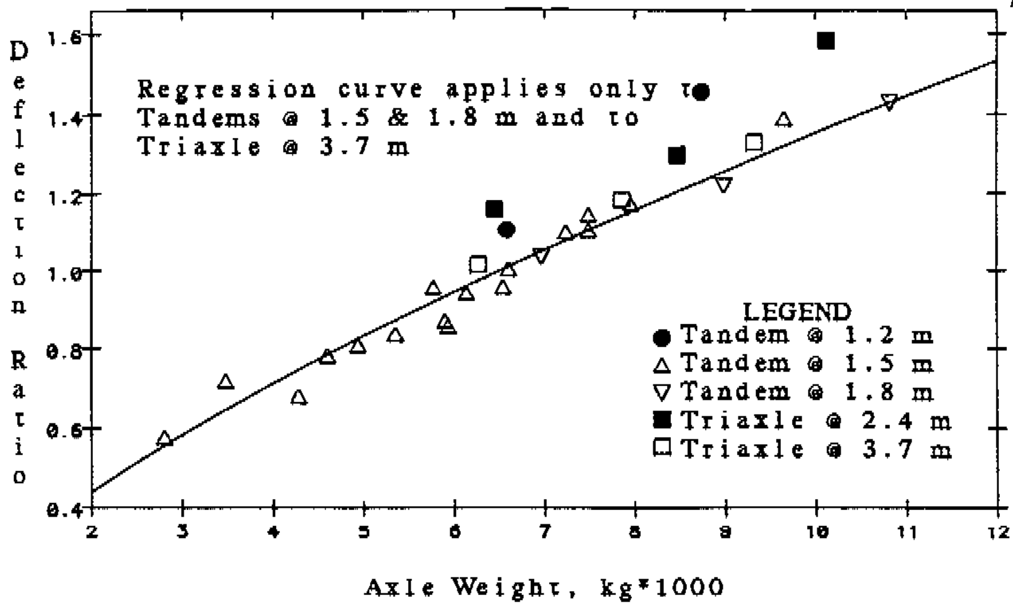


Figure A19: Deflection Ratios for Lead Axle
Site 9, Alberta

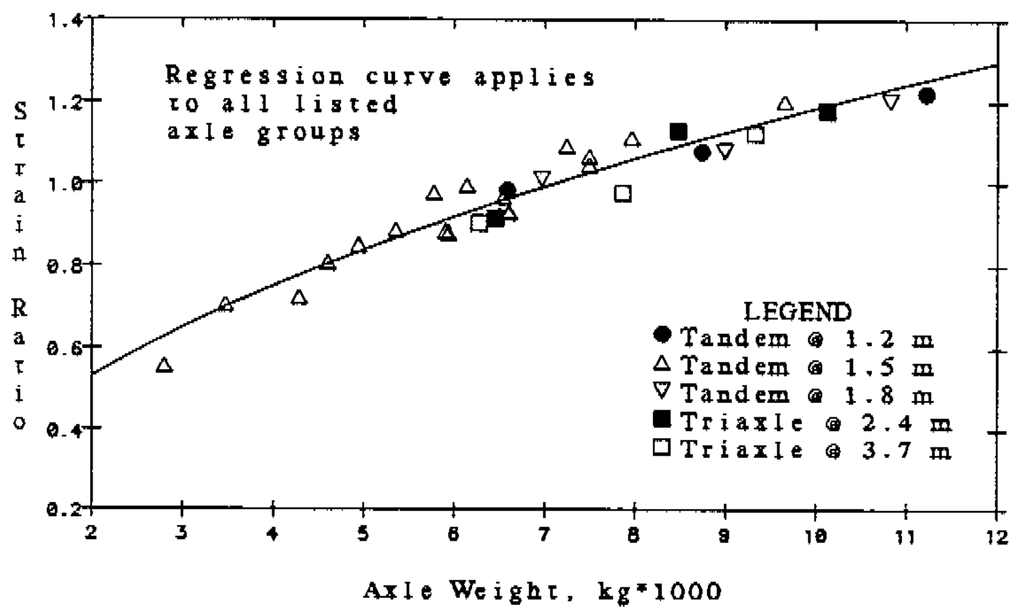


Figure A20: Strain Ratios for Lead Axle
Site 9, Alberta

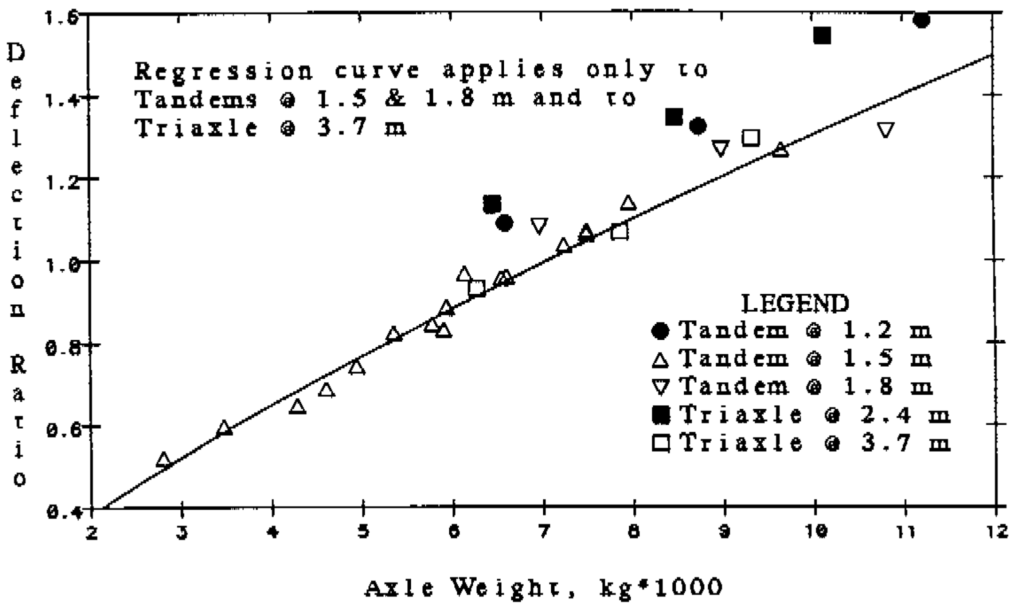


Figure A21: Deflection Ratios for Lead Axle
Site 10, Alberta

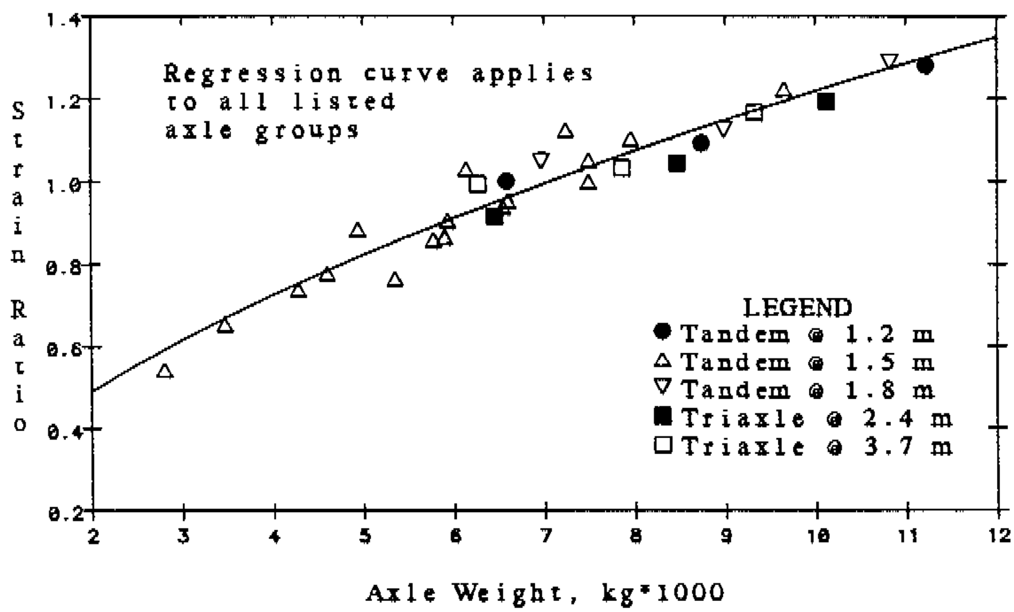


Figure A22: Strain Ratios for Lead Axle
Site 10, Alberta

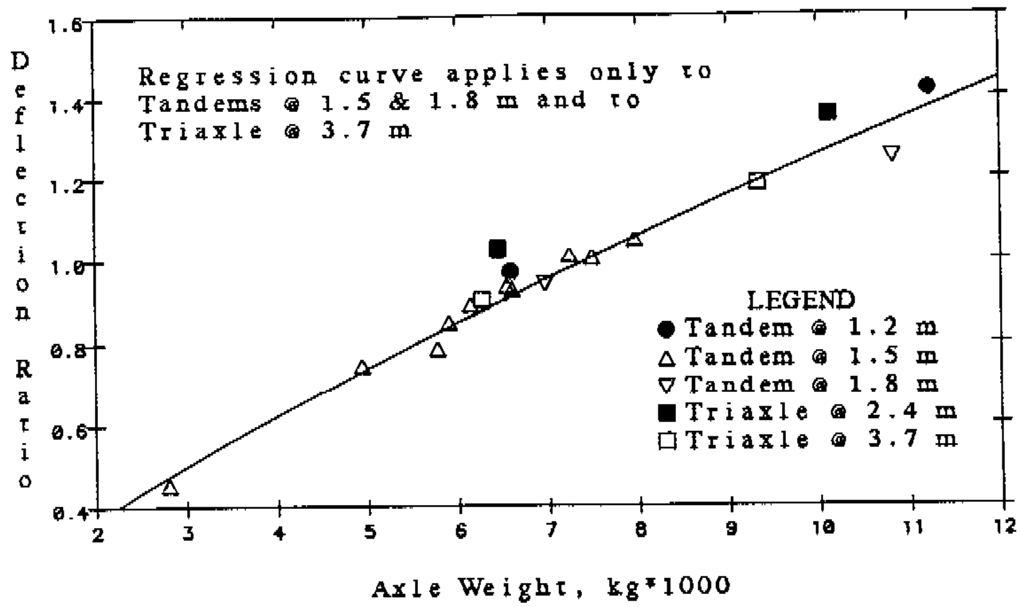


Figure A23: Deflection Ratios for Lead Axle
Site 11, British Columbia

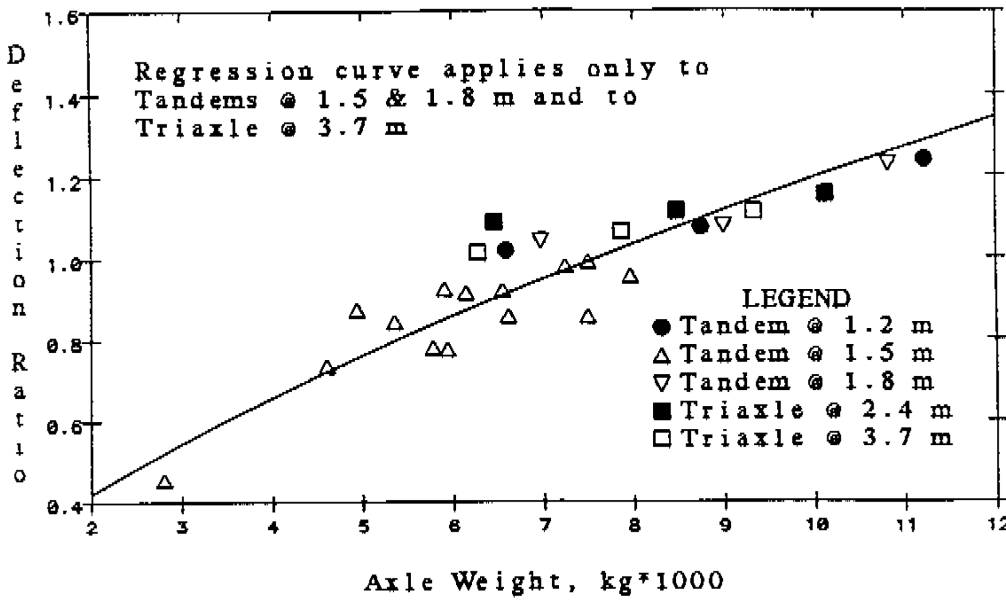


Figure A24: Deflection Ratios for Lead Axle
Site 12, British Columbia

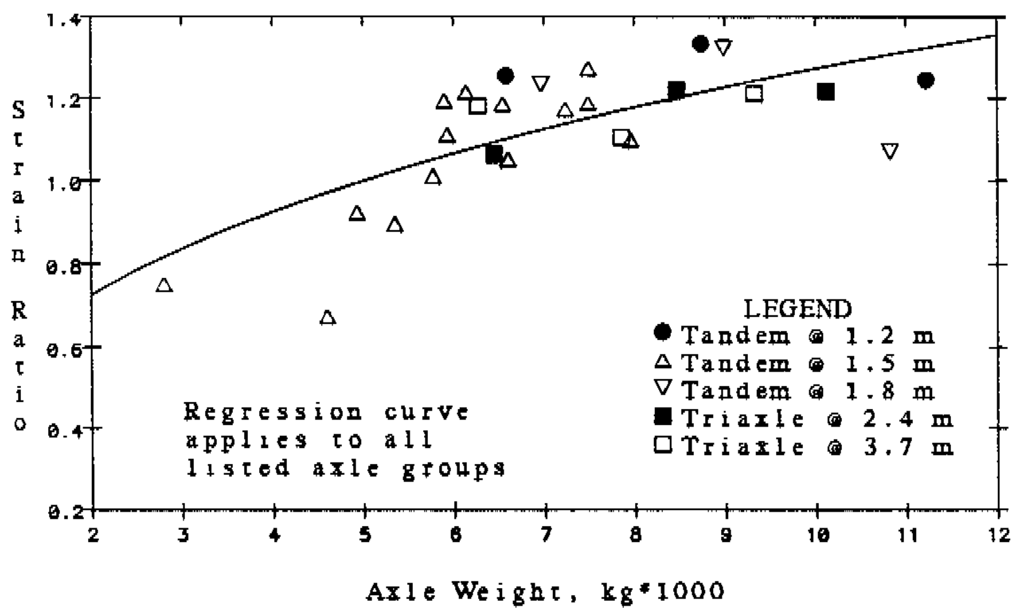


Figure A25: Strain Ratios for Lead Axle
Site 12, British Columbia

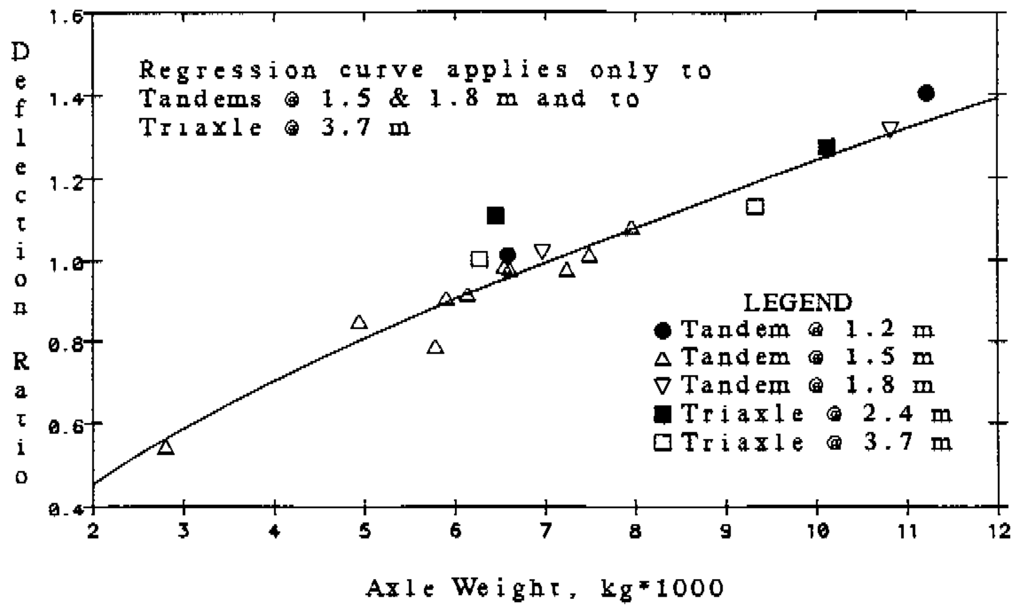


Figure A26: Deflection Ratios for Lead Axle
Site 13, British Columbia

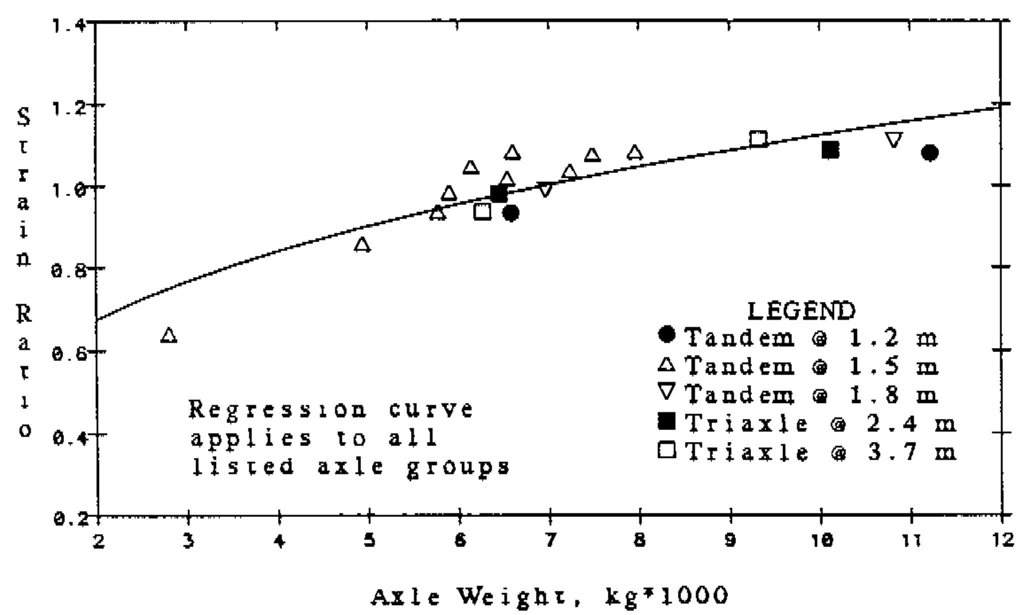


Figure A27: Strain Ratios for Lead Axle
Site 13, British Columbia