Impact of changes in vehicle weight legislation on pavements in Alberta, Canada

K. O. ANDERSON, J. A. BERVELL and S. TEPLY

In 1988 the Canadian Council of Ministers of Transportation under the Roads and Transportation Association of Canada (RTAC now TAC) made recommendations for a common set of truck weight and dimension limits on highway pavements in Canada. This effort was aimed at ensuring uniform interprovincial regulations in order to improve the efficiency of the trucking industry. The changes were implemented in Alberta in 1988. One-year "before" and "after" data from an instrumented traffic counting and weigh-in-motion site on a major 4-lane rural arterial highway in Alberta were used to investigate the impact of increased axle weight limits and different axle configurations on the pavement structure. This paper describes the data set-up, analytical process used and illustrates the severity of the impact on pavements using a design example. The analysis indicates that the one-directional average daily traffic increased some 12%, from 13 000 vehicles/day in 1986 to 14 600 in 1989. Although the percentage of trucks only increased from 10 to 11.8%, the equivalent single axle loads (ESALs), were almost 70% higher. Based on these data, it appears that the impact of the changes in trucking regulations is significant.

1. INTRODUCTION

1.1 Background

The prime considerations in determining the expected traffic loading on a pavement structure are the number of trucks and the magnitude and repetitions of axle loadings. Motivated by concern for protecting pavements from the effects of heavy loads, highway agencies apply limits on the weights of truck categories. Changes in truck weight limits can affect highway pavement maintenance costs, safety margins of bridges, accident frequency, highway congestion and traffic operations. These changes occur as a direct result of the increase or decrease in the loading and amount of truck traffic on the highway after truck weight legislation changes.

In 1988 the Canadian Council of Ministers of Transportation under the Roads and Transportation Association of Canada (RTAC, now TAC) made recommendations for a common set of truck weight and dimension limits on highway pavements in Canada. This effort was aimed at ensuring uniform interprovincial regulations.

This paper describes a study which investigated the truck usage pattern of a major four-lane roadway, with a focus on changes brought about by the adoption of the new axle weight limits and axle configurations in 1988. One year of "Before" and one year of "After" data from a traffic count and weigh-in-motion (WIM) scale installed on a four-lane primary highway in central Alberta were used to that end (ref.1).

Specific objectives of this study were as follows:

- To develop representative lane distribution factors for trucks from the WIM scale data, for comparison with distribution factors reported in the literature and used in current practice.
- To analyze the equivalent single axle load (ESAL) factors generated by various truck types in both lanes, and also the seasonal variation in both ESAL factors and loading trends.
- To assess changes in truck axle configuration and axle load distribution after the changes in vehicle weights and dimensions were implemented in 1988.
- To evaluate the projected impact of the new vehicle weight and dimension changes on pavement structure requirements.

1.2 Canadian (TAC) Recommendations

These limits were aimed at improving highway safety, protecting highway pavements against the destructive action of different axle configurations, and ensuring uniform inter-provincial trucking regulations. The recommendations suggested the use of four heavy truck configurations, whose axle arrangements would ensure maximum freight loads with minimal destructive strains on pavements. The recommendations were adopted from the results of studies undertaken on the impact of truck axle groups and configurations on pavement damage, which revealed the need for an optimal axle group spacing to reduce pavement damage (refs.2-4).

The recommendations sought to make uniform the dimensions of trailers, the limits of axle loads and the gross vehicle weights (GVW) within the provinces. Other regulated aspects of trucks which were touched upon included the maximum spread of axles, inter-axle spacings, drawbar lengths, overhangs, etc. The summary in Table 1 shows an overview of the TAC maximum allowable weight limits on front steering, single carrying, tandem and tridem axles. These values show changes from previous established standards and are reported to be justified in terms of net accrued benefits; that is in terms of trucking productivity benefits less increased road and bridge costs (refs.5-7).

Heavy vehicles and roads: technology, safety and policy. Thomas Telford, London, 1992.

Table 1. TAC Recommended Maximum Axle Weights

AXLE TYPE	MAXIMUM WEIGHT ALLOWED (tonnes)
Steering Axle	5.5
Single Axle (Dual Tires)	9.1
Tandem Axle	17.0
Tridem Axle	
(Variable 2.4 m to 3.0 m	21.0
with axle 3.0 m to 3.6 m	23.0
spread) 3.6 m to 3.7 m	24.0

For the sake of uniformity in weights and for inter-provincial trucking efficiency, TAC also reviewed the gross combination weights of trucks and defined four broad truck categories. Table 2 shows gross weight limits for these recommended trucks. The provinces of Alberta, British Columbia and Saskatchewan had adopted a prior recommendation which allowed for a maximum of 25.0 m overall vehicle length and 16.2 m semi-trailer lengths as opposed to the later standards of 23.0 m and 14.65 m respectively (ref.8). The recommendations resulted in a general increase of gross truck weights. A study by Nix reported an average increase of 10 tonnes on gross vehicle weight over the previous weight limits across Canada (ref.7).

1.3 Previous Weight Limits

Prior to the TAC recommendations in 1988, provincial jurisdictions in Canada set axle load limits arbitrarily with little reference to the economic trucking of goods between provinces. Each province established its axle load limits based on the need to maintain a reasonable level of serviceability on its road network and the available funds for annual rehabilitation and maintenance programs. This resulted in inconsistent axle load limits across jurisdictional boundaries. The 1986 study conducted by Nix et al. on vehicle weight and dimension regulations across the provinces highlighted the existing variations (ref.4).

The liberal regulations of some provinces led to the operation of different vehicle configurations that were not entirely desirable from the viewpoint of vehicle stability and handling. Other factors were the adverse effect of axle group loadings on pavement performance, as the provinces differed in highway construction standards, and the different tractor and trailer lengths which influenced the interaction between the truck and roadway geometrics.

These factors led to the series of studies which resulted in the 1988 TAC recommendations for truck weight and dimension regulations for all 10 provinces and 2 territories.

Table 2. TAC Recommended Gross Vehicle Weights

TRUCK TYPE	MAXIMUM ALLOWABLE GVW (tonnes)
Tractor Semi-trailer	
- 5 axle trucks	39.5
- 6 axle trucks	46.5
A-Train double	53.5
B-Train double	62.5
C-Train double	53.5

1.4 Limits in Alberta

Before the interprovincial regulations, weight limit enforcement in Alberta was based on the authorized load, revised in 1974. The allowable legal maximum gross vehicle weight was increased from 72 kips to 80 kips in 1974. The "optimal" truck configuration, the largest truck allowed under the regulations, according to Nix et al., was the 7-axle double with two trailers. The 7-axle double truck type had a weigh out limit of 53.5 tonnes with trailers which measured up to 2 m x 8.5 m but could be heavier or longer on some highways by special permit. These dimensions gave a maximum cube of 115 m^3, disregarding larger combinations and special permit requirements.

1.5 TAC Standard Trucks

To allow the trucking industry to acquire and operate trucks through all provincial jurisdictions, four standard configurations of tractor trailers were recommended by RTAC in 1988. The four categories of trucks were:

Category 1 : Tractor Semitrailer
Category 2 : A-Train double
Category 3 : B-Train double
Category 4 : C-Train double

These various tractor semitrailer configurations were proposed to allow for higher productivity within the bounds of acceptable stability performance and infrastructure impacts.

2. WEIGH-IN-MOTION SCALE SYSTEM (WIM)

2.1 General

The weigh-in-motion (WIM) scale system was installed near the City of Leduc in 1982. Traffic is weighed and counted in the northbound lanes of section 2:30 of Highway 2, a primary four-lane rural arterial roadway linking Edmonton and Calgary, the two major population centers in Alberta, each with populations in the order of 3/4 million.

The scale was manufactured by International Road Dynamics (IRD) and provides data on vehicle classification, axle and gross vehicle weights and vehicle speeds. Traffic data from the scale are stored in computer files and transmitted to departmental offices of Alberta Transportation and Utilities in Edmonton. All vehicles passing the scale are weighed, with the exception of those failing to trigger the scale or those missing the scale entirely. Despite year round operation of the WIM system, incidents such as power interruptions etc., resulted in less than complete data. Proportional adjustments were then made to account for the missing data.

2.2 Format of WIM Station Data

Traffic data are compiled weekly and include a summary of the following statistics:

- Number of vehicles and ESALs by lane and day of week.
- Average axle weights in tonnes by vehicle type.
- Car and Single Unit Truck volumes by day and hour.
- Five-axle Semi's and "Other" Truck volumes by day and hour.
- Speed distributions.
- Number of truck axles by weight.
- Weight distribution in tonnes and average ESAL by type.

- o Average axle spacing in metres by vehicle types.

3. TRAFFIC STATISTICS

3.1 Vehicle Classification

The vehicle classification system adopted at the WIM site distinguishes 19 types of vehicles on the basis of axle number and spacing, as well as weight of the second axle. Light vehicles such as cars and pickup trucks, including those pulling trailers, are classed as types 1 or 2. Two-axle six-tired to four-axle single unit trucks are classed as types 3 to 8. Five-axle semi's and trailer combination trucks are of types 9 to 19.

The 17 truck types have been grouped into two broad categories as light and heavy trucks, for load analysis purposes. Trucks categorized as types 3 to 8 (2 axle single unit to four axle trucks) are described as light trucks, while trucks with more than five axles (types 9 to 19) are referred to as heavy trucks.

3.2 Traffic Volume and Composition

Data from 1986 and 1989 were used to provide a basis for assessing changes in truck loading and volumes after the truck weight limit legislation was implemented in 1988.

The one directional Average Annual Daily Traffic (AADT) based on 34 weeks of data in 1986 was 6,500 vehicles per day (13,000 veh/day in both directions assuming an equal directional split). In 1989, the one directional AADT for the 48 weeks of data collected was 7,300 veh/day, indicating a greater than 12 percent increase in general traffic volume between 1986 and 1989 at the WIM scale site.

Trucks made up about 10 percent of 1986 weighed traffic, and about 12 percent of 1989 weighed traffic. Average daily truck traffic (ADTT) volumes were 1300 trucks per day in 1986 and 1720 trucks per day in 1989. These volumes indicate a 32 percent increase in ADTT between 1986 and 1989.

The proportion of truck types in the traffic stream is shown in Fig. 1. The predominant truck type is the five-axle semi and trailer truck, which is classed as type 9. In 1989, type 9 trucks made up about 40 percent of all weighed trucks, while heavy trucks represented about 70 percent of all weighed trucks.

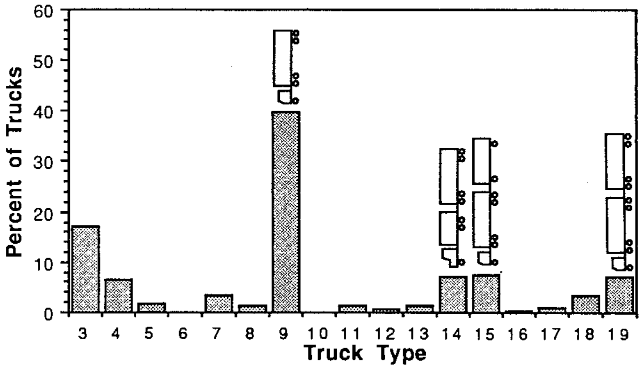


Fig. 1. Truck Types in the Traffic Stream

4. EQUIVALENT SINGLE AXLE LOADINGS

4.1 General

In addition to information on the number of vehicles in each lane of a highway, the total number of axles and the magnitude of loads imposed on the pavement by each axle must be known to accurately predict the accumulated number of wheel loads in a highway lane.

Most pavement design procedures now in general use are based on empirical considerations coupled with the evaluation of cumulative loading effects. These procedures define the design thickness of the pavement as a function of the number of applications of a standard 18 kip (80 kN) equivalent single axle load (ESAL). The numerical factors that relate the number of passes of an 80 kN single axle load needed to cause pavement damage equivalent to that caused by one pass of a given axle load are called ESAL factors or traffic equivalency factors. The relationships established at the AASHO Road Test are used by many agencies for this purpose (refs.9,10).

Weigh-in-motion technology has made WIM scales suitable for continuous axle load data recording and ESAL factor estimation (refs.11,12). At WIM scale sites, ESAL factors for individual vehicles are converted from recorded axle loads using the various ESAL versus axle load relationships of the AASHO road test or the relationships proposed by the Asphalt Institute (ref.13). These expressions are incorporated in the scale's computer system which allows an instantaneous computation and recording of the estimated ESALs. Daily ESAL repetitions are calculated by summing ESAL factors of individual vehicles. WIM scales categorize groups of axles passing as single, tandem or tridem axles depending on the detected distance between the centers of two or three successive axles. Incorporated equivalency expressions are automatically applied to axle load groups to determine the ESAL factors.

At the Leduc WIM site, the AASHO equivalency factor expressions for flexible pavements and a modification of these expressions to account for single and tandem steering axle weights are used. The expressions used for the ESAL factor conversion at this scale are given by Lowe et al. (ref.14),as follows:

For Single steering axles: $N_{18} = (L/11.5)^{3.30}$

For Tandem steering axles: $N_{18} = (L/28)^{3.30}$

For Single and Tandem carrying axles:
$L_2 = 1$ for single axles and 2 for tandem axles

For Tridem Carrying axles: $N_{18}=(L/47)^{4.49}$

All axle weights (L) are expressed in lbs x 10^3 (kips). Mixed Imperial and SI units are presented in the WIM scale data. ESAL values are presented in terms of 18 kip ESALs, while axle loads and dimensions are in tonnes and metres respectively.

Other design procedures define the design thickness of the pavement as a function of the representative frequency distributions of axle weights for single, tandem and tridem axles on trucks using the highway. Typical of this is the rigid pavement thickness design procedure of the Portland Cement Association (ref.15), which will not be discussed in this paper due to space constraints.

4.2 Daily ESALs

Daily cumulative ESALs generated during 1986 and 1989 are shown in Fig. 2. As the WIM data was compiled weekly, the daily cumulative ESALs were determined by dividing the weekly totals by seven. High daily ESALs were generated in the summer months. In 1989, the greatest number of weekly ESALs were recorded in the second week of June. During this period, the average daily cumulative ESALs of numbered about 1400.

The average annual daily ESAL applications, disregarding non-classified vehicles, were 453 in 1986 and 770 in 1989. If it is assumed that the percent of missed trucks is proportional to the truck mix of the weighed vehicles, the average annual daily ESALs would be 605 in 1986 and 1025 in 1989.

4.3 ESALs by Truck Types

Heavy trucks generated about 90 percent of the total daily ESALs on the highway. The proportion of daily cumulative ESALs caused by the various truck types is shown on Fig. 3. The five-axle truck category (Type 9) produced about half of the ESALs while the seven-axle trucks (Types 14 and 15) contributed over 20 percent.

A comparison of the ESAL factors for each truck type for the two years is presented in Table 3. The average number of ESALs per pass (ESAL factors) for trucks of five or more axles (heavy trucks) increased between 1986 and 1989. Since ESALs vary exponentially with axle weight, small differences in average weight or in the distribution of weight between axles cause large variations in ESALs.

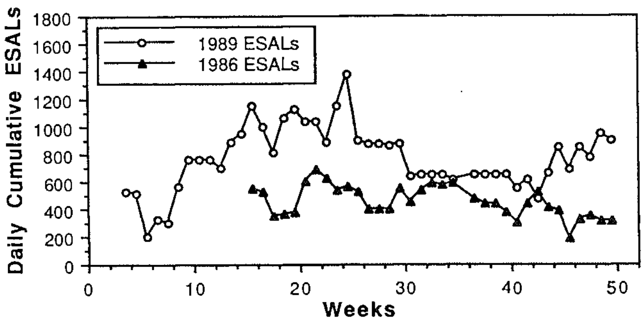


Fig. 2. Daily Cumulative ESALs

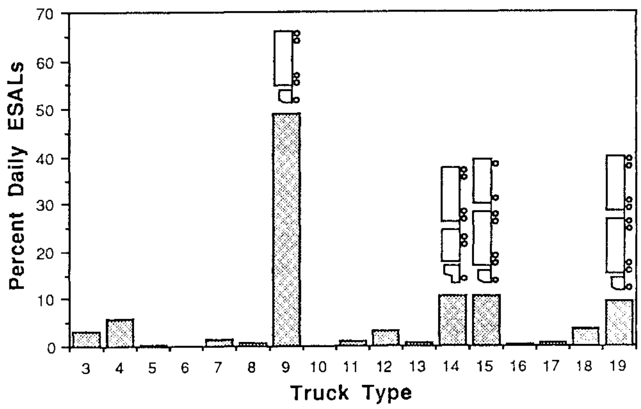


Fig. 3. Percent of Daily ESALs by Truck Types

Table 3. ESAL Factors for Classified Trucks

Truck Type	1986 ESAL Factor	1989 ESAL Factor	Percent Change
3	0.18	0.21	16.7
4	0.78	1.05	34.6
5	0.30	0.29	-3.3
6	0.40	0.65	---
7	0.53	0.47	-11.3
8	0.80	0.62	-22.5
9	1.32	1.67	26.5
10	0.36	0.88	---
11	1.18	1.37	16.1
12	2.71	4.29	58.3
13	0.82	0.92	12.2
14	1.87	2.51	34.2
15	1.84	2.41	31.0
16	0.71	0.93	31.0
17	0.99	1.04	5.1
18	1.21	1.65	36.4
19	1.45	2.14	47.6

Five-axle single and semi-trailer trucks were the predominant truck types at the site in both years. Five-axle trucks (types 9,10 and 11) represented 45 percent of all weighed trucks and caused about 54 percent of all generated ESALs. From 1986 to 1989, the ESAL factor for five-axle semi-trailer trucks increased by over 26 percent.

Six-axle trucks (types 12 and 13) represent 2.1 percent of all trucks. These truck types generated the highest average ESALs per pass (4.29 ESALs/veh) but contributed only about 4 percent of the total ESALs in 1989. About 0.5 percent of these trucks generate ESAL factors greater than 15.5, which indicates gross truck overloading.

Seven-axle truck volumes represent 13 percent of all trucks and cause 22.6 percent of total generated ESALs. The axles of these trucks are arranged in various forms. Trucks having configurations of a single front axle and three tandem axle groups generate the largest ESAL factors on the highway. The average ESAL factor for these truck types is 2.51 ESALs/veh. At least one out of every 150 trucks classified in this category generated an ESAL factor over 12.5 in 1989, again indicating gross truck overloading.

Eight-axle trucks (types 17 and 18) generated ESAL factors averaging 1.51 ESALs/veh. Gross vehicle weights of up to 80 tonnes (175 kips), resulting in up to 25 damaging units per pass, were recorded on eight axle and undefined-axle trucks (type 19). The average ESAL factor for type 19 trucks was 2.14.

For all truck types, average ESAL factors of 1.05 and 1.4 were calculated for 1986 and 1989 respectively. Heavy trucks represented 64 percent of 1986 weighed trucks with an average ESAL factor of 1.41. In 1989, heavy trucks produced an average of 1.9 ESALs per pass. These data suggest an increased use of large combination trucks and an increase in the payloads of these trucks after the 1988 changes in truck weight legislation.

4.4 Daily ESAL and Truck Volumes

Using truck load data from 1989, regression analyses were carried out to obtain a relationship between daily cumulative ESALs and ADTT. Vehicle loadings in both the inside and outside lanes were analyzed, and the best fit line for the combined data from both northbound lanes is shown in Fig. 4.

A close relationship exists between daily ESALs and the truck traffic volumes for the combined as well as individual lanes. A regression coefficient of 0.90 was calculated for both lanes , almost identical to the correlation (R2 = 0.91) that was observed between the two variables in the outside lane. A poorer regression coefficient of 0.61 was obtained for the inside lane alone.

4.5 Accumulated ESALs

The accumulated number of ESAL repetitions from all vehicles reflects the amount of potential pavement damage from traffic loadings. Comparisons of eight months (between April and December) of weekly accumulated ESALs for 1986 and 1989 are shown on Fig. 5.

Because ESAL data was not available for several weeks in 1986, the missing data have been interpolated using the average ESALs within each seasonal period. The period shown in Fig. 5 starts in April which coincides with the normal start of the period for a non-frozen subgrade in this climatic area.

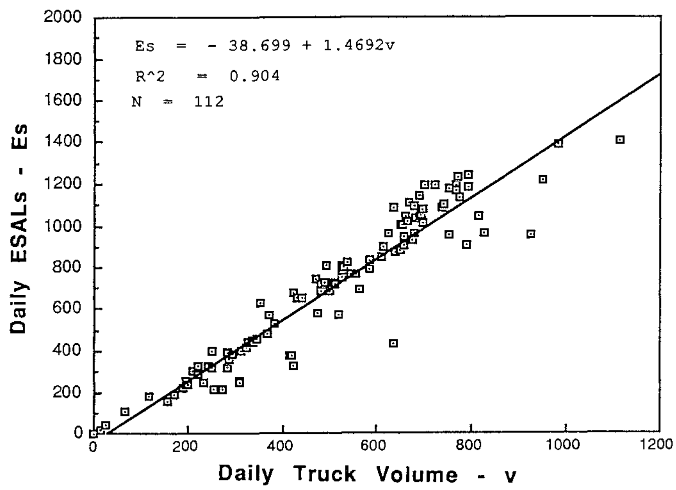


Fig. 4. Daily ESAL and Truck Volume Relationship

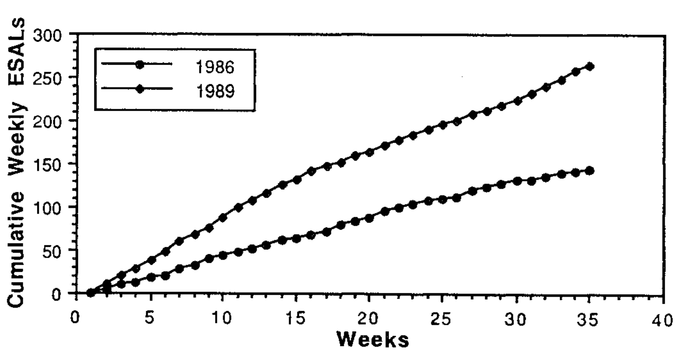


Fig. 5. Cumulative ESALs in 1986 and 1989

Between 1986 and 1989, there was a greater than 80 percent increase in accumulated ESALs, due to an increase in the volumes of heavy combination trucks (truck-trailer and combination units) in the traffic stream, and an increase in the payloads of heavy trucks. The increase in loading is in response to increased load allowances as well as the economic advantages associated with using the larger truck configurations.

4.6 ESAL Distribution

A plot of ESAL factors versus gross vehicle weight for light and heavy trucks is shown as Fig. 6. This plot shows the relative damage caused by the gross weight of each truck category. It is seen that a close relationship exists between damage units (ESAL factors) and truck gross weights. This relationship shows good agreement with the fourth power rule generally used to express relative damage from increased axle loads.

Fig. 7 illustrates the distribution of truck numbers versus generated ESAL factors for type 9 five axle trucks. This plot is useful in assessing the proportion of trucks over the set weight limit for each truck type.

4.7 Truck Overloads

A significant factor contributing to early pavement wear and the deterioration of road structures is the destructive effect of overloaded trucks. The term overloaded, as used in this paper, describes trucks with axle loads or gross vehicle weights exceeding allowable limits. ESAL factors increase rapidly when weight limits are exceeded. For example, a 10 tonne increase in gross weight of a five-axle

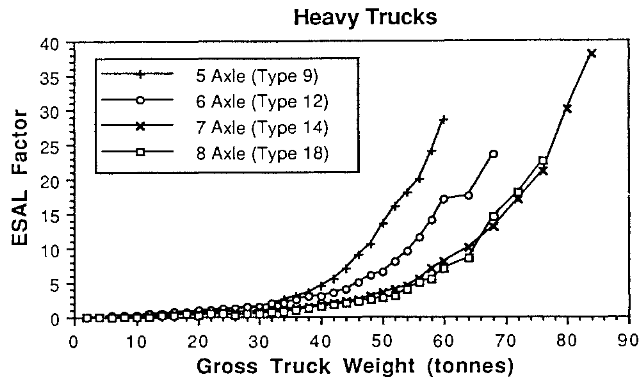


Fig. 6. Relative Damage by Gross Vehicle Weight in 1989

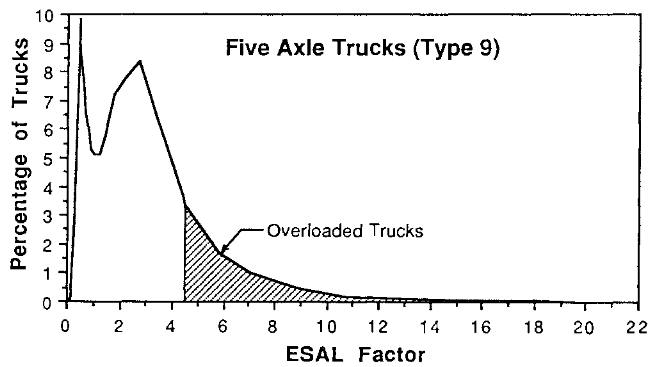


Fig. 7. Distribution of ESAL Factors for Type 9 Trucks

truck over its GVW limit 39.5 tonnes results in the damage units increasing from 4.5 to 13 ESALs. Other truck types show similar characteristics in loading and damaging values.

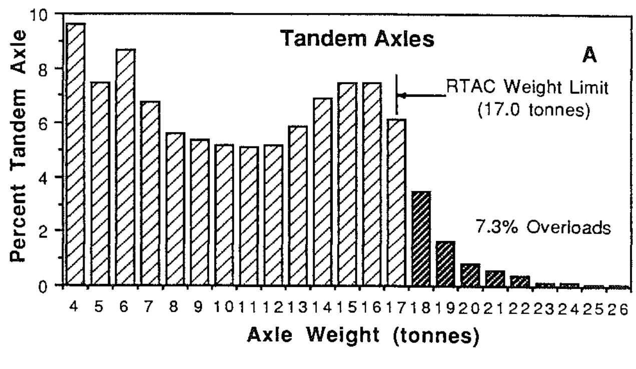
Approximately 3.4 percent of all weighed trucks were overloaded in 1989, and this proportion of trucks caused over 17.5 percent of total generated ESALs. Nearly 26 percent of type 12 trucks (6-axle semi) were overloaded. Although only 4.4 percent of 5-axle semi trucks were overloaded, more than 50 percent of total overload ESALs were generated by this truck category. Overloaded trucks generated an average ESAL factor of 7.0 ESALs/vehicle.

The proportions of tandem and tridem axles which are overloaded are summarized in Figs. 8a and 8b. The increased use of tridems in 1989 resulted in a higher proportion of overloads (12.5 percent of all weighed tridems) within this axle category.

4.9 Lane Distribution

In addition to the number of trucks and the ESALs generated on the highway, the selected lane for travel is important in the design of pavement and the operation of traffic on the highway. As shown by Darter et al. (1985) and the Portland Cement Association, PCA, (1984), the majority of truck traffic uses the outside lane for travelling on multilane highways. However, as the lanes of the highway become congested from increased traffic, more trucks in the traffic stream will tend to use the inner lanes.

About 74 percent of all northbound traffic at the WIM scale site was found to travel in the outside right lane (lane 1). This proportion did not vary significantly with time of year or between years. The outside right lane accommodates approximately 90 percent of total truck traffic volumes and about 85 percent of the one-directional accumulated ESALs.



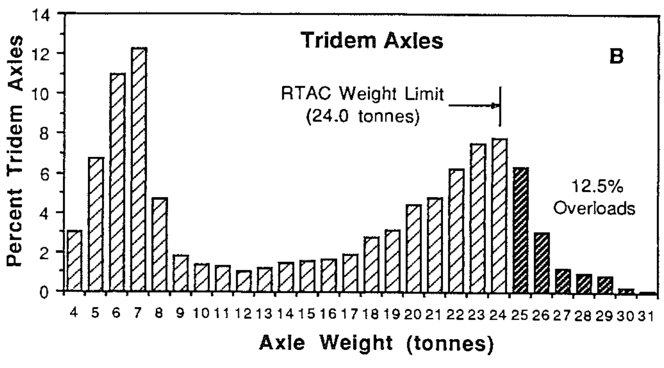


Fig. 8. Axle Weight Distribution for Tandem and Tridem Axle Trucks

In comparing these lane distribution factors with those suggested by the PCA (ref.15), it is found that a greater proportion of trucks use the right lane on Highway 2 than predicted. For a one directional ADT of 7,300, the PCA chart suggests that 82 percent of all trucks will travel in the right lane of the highway.

The actual lane distribution factors are within recommended AASHTO guidelines (ref.16), which suggest that between 80 and 100 percent of 18 kip ESAL traffic will use the outside lane of a four-lane highways.

5.0 DESIGN IMPACTS OF WEIGHT CHANGES

5.1 General

Changes in the distribution of gross vehicle weights and different axle arrangements on trucks increase the wear impact on pavements. Analysis of truck weight data before and after the implementation of the RTAC weight changes has shown significant increases in truck axle loads and corresponding increases in the damage units applied to the pavement structure.

Although the increased loading will increase required rehabilitation of existing pavements, this paper also investigates the impact of the weight changes on the estimated thickness of new flexible pavements. The Asphalt Institute method of flexible pavement thickness design (Asphalt Institute, 1981), is used to determine the thickness of flexible pavement required to support the 18 kip (80 kN) ESAL repetitions generated by vehicles before and after the implementation of the RTAC recommendations.

5.2 Design Input

Truck volumes and ESAL factors were presented previously. Assuming the traffic mix on Highway 2 does not change throughout the chosen 20 year service life of the pavement and using a general annual traffic growth rate of 4 percent, the design ESALs can be determined. The rate of truck traffic growth between 1986 and 1989 was found to be 10.8 percent, rather than the 4 percent used in the analysis. This period of rapid growth was believed to be due to the weight legislation changes, and is not representative of long term growth patterns.

The accumulated ESALs for the section of roadway under investigation were calculated using an LDF of 0.9. The proportions of each type of truck were held constant throughout the design period, and multiplied by the growth factor of 29.8, based on the 4 percent annual growth rate. Accumulated ESAL applications for all truck types total 12 x 10^6 ESALs, based on the data from 1989.

Using the percentage of gross truck overloads for each truck type, accumulated ESALs due to overloads expected within the 20 year design period have been calculated based on the 1989 truck volumes and weights. Total ESALs from overloading at the end of the design period will be 2 x 10^6 applications, about 16.9 percent of the accumulated destructive units on the pavement.

The design ESALs based on the 1986 truck volume and weight data were calculated to be 7 x 10^6 applications. An average subgrade resilient modulus of 30 MPa was chosen for use in the design analysis.

5.4 Pavement Thickness Evaluation

The minimum full-depth Asphalt Concrete pavement thickness required for the design ESALs is obtained by using the design chart in the Asphalt Institute's Pavement Design Manual (ref.13).

From this design chart, the minimum thickness for 12 x 10^6 ESALs, the total accumulated ESALs from the 1989 data, is 390 mm. Eliminating the overloaded ESALs of 2 x 10^6 would reduce the required thickness by 10 mm, to 380 mm.

The 1986 truck loading, which would have resulted in 7 x 10^6 accumulated ESALs over 20 years, requires a minimum full depth asphalt thickness of 360 mm. From this it may be concluded that the 1988 weight change legislation will necessitate an additional full depth asphalt thickness of approximately 30 mm, to achieve comparable pavement performance.

6.0 FINDINGS

Increases in average truck axle weights, changes in truck traffic composition and increases in truck volumes have contributed to significant increases in total ESALs since the 1988 changes in truck weight regulations.

The cumulative ESALs generated in 1989 were about 1.8 times the cumulative ESALs from 1986. The average ESAL factor increased from 1.05 in 1986 to 1.4 in 1989.

The predominant truck type was found to be the five-axle semi-trailer truck (Type 9). This type of truck contributes over half of the total accumulated ESALs.

Overloaded trucks represented 3.4 percent of all trucks, but caused about 18 percent of the total ESALs. Combination trucks with six or seven axles are the most commonly overloaded types, while tridems are the most likely axle group to be overloaded.

In general, about 90 percent of all truck traffic uses the outside lane, generating about 85 percent of total ESALs.

Seasonal variations in generated ESALs relate closely to the number of trucks on the highway. High ESALs are generated in the spring and summer months. Truck volumes and loadings are at their lowest during the winter, the least critical period with respect to their impact on pavements.

Implementation of the TAC recommendations on truck weight limits have produced increased ESAL loadings which are estimated to result in a 30 mm additional asphalt concrete 20 year design thickness requirement or an increased rate of highway rehabilitation. Eliminating trucks operating over the set weight limits would reduce the additional asphalt thickness by 10mm.

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