DETERMINING THE COST OF SPECIAL TRIP PERMITS AS A FUNCTION OF ROAD DAMAGE

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SUMMARY

This article proposes to use the evaluation of the damage caused by heavy vehicles to established the cost of a single overload permits. The Quebec Legislation holds that, in order to move an indivisible extra-heavy load, the carrier must, through a request for an itinerary study, obtain a single overload permit. The heavy vehicles concerned by this legislation can be conventional (tractor-semitrailer), low-bed multiaxles or mobile cranes. Presently, the cost of this permit is only 10$. This fee does not reflect the problems and damages caused by this type of transportation. From the results of a R.T.A.C. study on weight and dimensions, and with the help of data from other similar research, it is possible to evaluate the damage caused by different types of vehicles. Among the parameters considered, are the axial load, the type of tires and their arrangement, the axle spread, the type of road and the time of year. When comparing the damage caused by an extra-heavy vehicle to the one caused by a vehicle in conformity with the legal norms carrying the same load in more than one trip, it is possible to evaluate the excess damage that would be caused by the carrier who requested the permit.

A previous evaluation estimated at 0.02$ per kilometre the cost of maintenance inherent to the passage of a standard axle. With a formula that takes into consideration the excess damage, the unitary cost of maintenance and the distance covered, it is possible to establish the cost of the single permit. Minimum and maximum fees should also be established in order to be consistent with other types of permits, with the cost of eventual infractions and with the economy of this type of transportation. Examples of the calculations used to evaluate the damage and the cost for three types of vehicles are presented. Even if most of the basis of the calculation are well accepted by the scientific community, some call for extrapolations. There is still place for more studies, especially concerning the low-bed multiaxles.

1. INTRODUCTION

Most industrialized countries are now aware of the problems of road deterioration. Important studies are carried out to evaluate the pavement performance and the impact of heavy vehicles. Moreover, we are now reconsidering the methods used to finance our roads and we are trying to incite carriers to use the least damaging vehicles possible.

In this context, the present paper suggests a logical continuity between the studies by experts on pavements and their pratical application as far as the user's financial participation is concerned. More specifically, the notions of damage evaluation caused by heavy vehicles are used to established the cost of single overload permits.

In the following pages, we will first examine the place of extra-heavy load special single permits in the Quebec Legislation along with the type of vehicles concerned. We will also look at the actual fees and their inconsistency in comparison with the problems and the damages caused by this type of transportation.

Since the principle of tarification implies an evaluation of the damage, we will look at the methods used to assess this damage. We will review the principal parameters used to calculate the relative damaging effects and we will discuss their reliability. Subsequently, we will present the formula used to evaluate the cost of the permit. This formula takes into consideration the excess damage, the unitary maintenance cost and the distance covered. We will briefly examine how the unitary maintenance cost was previously evaluated. The need to established minimum and maximum fees will also be discussed.

After examination of calculation examples for three types of vehicles, we will sum up the advantages for this tarification principle and we will suggest new studies on the impact of heavy vehicles on the roadways.

2. QUEBEC LEGISLATION

In Quebec, the authorized legal weight on a heavy vehicle is established by the Regulation on load and dimension norms (Réglementation sur les normes de charges et de dimensions). The axial load authorized is established according to axle configuration and spread. The authorized gross weight is equal to the sum of the authorized axial loads minus, if needed, an adjustment that takes into account the spread between each axle system. The authorized maximal loads are: 8 500 kg for steering axles, 10 000 kg for single axles, 20 000 kg for tandem axles and 30 000 kg for tridem axles. The maximum gross vehicle weight is 57 500 kg.

In accordance with the Directive on special traffic permits (Directive sur les permis spéciaux de circulation), a carrier can request a special permit to carry a load that exceeds the load authorized by the Regulation. The axial loads are then authorised according to the types of tires, the configuration and spread of the axles. The authorized gross weight is still equal to the sum of the authorized axial loads minus, if needed, an adjustment taking into account the spread between each axle system. For a single axle, the Directive authorises a maximal load of 14 500 kg. For tandem and tridem axles, the maximal load authorized is respectively 32 000 kg and 38 500 kg. The total gross weight authorized is 77 000 kg.

The vehicles that exceed the axial load or the gross weight stipulated in the Directive on special permits, must, according to article 633 of the Quebec Highway Safety Code (Code de la sécurité routière du Québec), obtain an overload single permit. This permit is delivered by the Ministry of Transport after an itinerary study determinating whether the works of art and the pavements will be jeopardized.

3. PRESENT TARIFICATION

Presently it only costs 10 $ to get a special overload permit in accordance with article 633 of the Highway Safety Code. On one hand, this symbolic rate does not allow to rationalize the extra-heavy transportation by means of a significant rate. On the other hand, the inconveniences caused by this type of transportation (possible traffic disturbance, necessity for Ministry experts to study itineraries, etc.) and the inherent risks of damage to works of art and roadways are not reflected in the present fees.

Some jurisdictions already take into account, in their Legislation, the problems and damages caused by overload transportation. To a minimum fee, they set an additional cost depending on the weight carried and on the distance covered [1].

An equitable fee should take into consideration the damage done to bridges and pavements by carriers with a single permit compared with that done by carriers in conformity with the norms.

4. DAMAGE EVALUATION

Three main categories of vehicles are likely to be subjected to special overload permits delivered in accordance with article 633. The first category includes conventional vehicles (tractor-semitrailer) with, sometimes, a jeep dolly. The second category includes the mobile cranes that, because of their configuration and their weight, cannot get a permit in accordance with the Directive on special permits. These two categories are equiped with two- or four-tire axles. The third category includes the low-bed multiaxles usually equipped with eight-tire axles.

A method to evaluate the damage caused by the first two categories of extra-heavy vehicles will be presented first. It is more difficult to evaluate the damage caused by the third category because of the special tire arrangement and because of the fact that few studies have been done on this type of configuration. However, a possible approach method to study the problem will be examined.

4.1. METHOD OF CALCULATING THE DAMAGE FOR 2- OR 4-TIRES AXLES

A calculation method to evaluate the relative destructive effects of heavy vehicles equipped with 2-or 4-tires axles has been developed by the soils and pavements department of the Quebec Transport Ministry (Service des sols et chaussées du ministère des Transports du Québec) [2]. By a 5-step approach, derived from the results of various studies, a Passage Equivalency Factor is firt calculated taking into account the axle load and configuration. Adjustment factors are subsequently introduced to account for the tire arrangement, the axial spread, the type of road and the time of year.

4.1.1. PROCEDURE

Step 1

At this stage, according to the axial loads, we evaluate the relative destructive effects of the axle (or axle systems) of the vehicle. To do so, we compare the damage caused by each axle with the damage caused by a standard axle. In Quebec, the measure representing the relative damaging effect of trucks, is the Passage Equivalency Factor (FEP). Thus, the passage of an axle for which the calculated FEP is "N", is equal to "N" passages of a standard axle or, in other words, is "N" times more damaging.

In Quebec, the Regulation allows 10 000 kg on a single axle. Because of this, and in order to facilitate the calculations and their understanding in the metric system, the standard axle is a single axle loaded with 10 000 kg and equipped with 1000-20 dual tires. The ratio between the Quebec FEP and the LEF (Load Equivalency Factor) used by the R.T.A.C and the A.A.S.H.O is 1: 2 (FEP=1 is equal to LEF=2).

The Passage Equivalency Factor used by the Quebec Ministry of Transport comes from studies done by the R.T.A.C. on the relative damaging effects of heavy vehicles on pavements [3] and from a Southgate and al. study at the University of Kentucky [4]. The R.T.A.C. has done some testing on Canadian roads to evaluate the Load Equivalency Factor for different loads on single, tandem and tridem axles. Based on the fatigue concept, and using the Chevron N-Layer program, Southgate and al. have calculated the Load Equivalency Factors for axial configurations of 1 to 6.

Figure 1 shows the Passage Equivalency Factors derived from the 2 sources mentioned above.

For example, loads of 12 500 kg on a single axle, of 22 000 kg on a tandem and of 55 500 kg on a 5-axle will make twice as much damage as the standard axle.

<u>Step 2</u>

Contact pressure and contact area between the tires and the pavement can influence the performance of the layers of the upper structure. The use of narrow or high pressure tires can, for instance, increase rutting and cracking in a significant way. Assuming that the 1000-20 dual tires of the standard axle do not require adjustement of the Passage Equivalency Factor (FEP), we can evaluate the adjustment factors for other types and arrangements of tires. Thus, these factors will reflect the fact that single tires are more damaging than double tires, and narrow tires more damaging than larges ones.

The correction factors shown on figure 2 have been developed from a mechanistic theory of multilayer pavement models and have been validated for the studies of Hallin and al. [5]. We can see, for instance, that the use of 1000-20 single tires on an axle would have the effect of multiplying the FEP by an adjustment factor of 5, while the use of 1600-20 dual tires would reduce it by more than twice.

<u>Step 3</u>

At this stage, the FEP is modified to take into consideration the axle spread. This adjustment is based on two assumptions. Since it is better, for a given load, to group the axles in order to reduce damage, there is however an axle spread beyond which the axles are considered independant. On the other hand, if the axle spread is too short, it can cause the stress bulbs of the wheels of each axle to overlap, thus causing the deformation of the lower layers of the pavement or of the subgrade.

Figure 3 shows the correction factors suggested [2] to take the spread into account. Deduced from recent studies by the R.T.A.C., these values illustrate that the optimal spread is 1,8 m. We can see that the adjustment factors are increased when the spread is increased or reduced.

Stage 4

Since the materials used and the thickness of the layers affect the stress distribution in the pavement structure, the FEP is adjusted according to road design.

With a formula developed by Coquand [6] from the French Laboratoire central des Ponts et Chaussées, derived from the tests made by the A.A.S.H.O.,the structural thickness is considered in calculating the Passage Equivalency Factor. Table 1 shows the correction factors that have been attributed [2] to each category of roads in Quebec according to their average typical structure. The unitary correction factor has been attributed to highways since, as we will see later, the unit maintenance cost has been evaluated for this type of road.

Step 5

Winter in Quebec causes a progressive and prolonged freeze of the roadways. During the spring thaw, the interstitial ice thaws from the surface but cannot easily drain into the underlying, still frozen, layers. This causes water saturation and a loss of compaction in the thawed layer leading to a great loss of bearing capacity.

Studies done by the Ministry of Transport [7] [8] on the bearing capacity during springtime, has demonstrated that the deflection on Quebec roads increases 48 % to 78 %. That implies that the damage caused by an axle will increase by 5 to 10 times during this period.

Table 2 shows the correction factors to be applied to the different road categories during the spring thaw.

4.1.2 DISCUSSION OF THE METHOD

This method has the advantage of being based on accepted scientific facts. Extrapolations are, however, necessary to evaluate the impact of heavy loads. For example, the R.T.A.C. did not evaluate the impact of loads exceeding 11 100 kg on single axles, 22 300 kg on tandem axles and 32 000 kg on tridem axles. Although the tendancy towards and exponential increase in damage as a function of a linear increase of the load seems to be established, it would be interesting to study the performance of roadways under extra-heavy loads to see at what moment permanent deformations of the structure will occur. Since the studies made on more than tri-axles have only been theoretical, it would be interesting to do on-site tests to verify the preciseness of the results. Finally, it would also be important to better detail the impact of the tires and accuracy of the axle spread.

4.2. METHOD OF CALCULATING THE DAMAGE FOR AXLES WITH MORE THAN 4 TIRES

Little research has been done to evaluate the damage caused by low-bed multiaxles. Because of their configuration, the methods used to calculate their relative destructive effects must take into consideration the proximity of the tires since the pressure bulbs can overlap and, ultimately, cause the rupture of the pavement.

We selected two studies that examine the damage caused by this type of vehicle and, at the same time, the influence of tire proximity. The first was done in Australia by Scala and Potter [9] and the second, by Epps et al. [10], complements the work of the U.S. Corps of Engineers.

The method suggested to calculate the damage combines the results from these two studies and those from the Quebec Ministry of Transport. It is divided in 7 steps. We should first mention, that because of the distinctive features of this type of vehicle, its speed, etc., we consider each axle as independant instead of considering it as part of an axle system.

4.2.1. PROCEDURE

Step 1

The object of this step is to evaluate the influence of tire proximity by establishing the influencing factors. We first measure the distance (dt) between the center of the tires on one axle. We then calculate the ratio of these distances to half the nominal section-width (dt/.5Wn) of these tires. These ratios are finally used to determine the influencing factors (Fi) with the help of Figure 4. An example of this procedure is illustrated at Figure 5.

Step 2

In addition to the proximity of the tires, we must consider the type of tires involved. This way, we try to establish the load on a tire that, if it were not influenced by the adjacent tires, would produce the same impact as the standard axle tire. First, knowing the nominal section width (Wn) of the tire, we can establish its contact width (Wc) (see figure 6). Once we have the approximate contact width, figure 7 is used to determine the equivalent load (EL_t).

Step 3

Before calculating the damage caused by each axle, we calculate the load that would produce the same damage as the standard axle. This load is calculated by the following equation (1).

$$(1)\quad L_{ESA} = N \left[EL_T \times 1/ \sum_{1}^{N} Fi \right]$$

L_{ESA} = Load producing the same damage as the standard axle

EL_t = Load on a tire that, if it were not influenced by the adjacent tires, would produce the same impact as the standard axle tire

ΣF_i = Total of the influencing factors related to the proximity of tires

N = Number of tires on axle

Step 4

Damage is finally evaluated with equations (2) and (3). We calculate the ratio between the axial load of the axle under study (La) and the load which, on this axle, would produce the same damage as the reference axle. This ratio is then elevated to the 4th power.

$$(2)\quad LEF = \left[\frac{L_a}{L_{ESA}} \right]^4$$

$$(3)\quad FEP = \left[\frac{LEF}{2} \right]$$

The total damage caused by the low-bed multiaxle is evaluated by multiplying the number of axles by the damage calculated with this formula, and the global vehicle damage is calculated by adding the damage caused by the low-bed multiaxle to the damage caused by the tractor.

Steps 5-6-7

These three steps correspond to steps 3-4 and 5 of the method to calculate the damage for 2- and 4-tire axles. Correction factors are applied to take respectively into account the axle spread (Figure 3), the type of road (Table 1), and the period of year (Table 2).

4.2.2 DISCUSSION OF THE METHOD

From a test conducted when carrying a 185-ton transformer, this method seems to give realistic results. We must however mention that integral use of the Australian team's method of calculation would give less damage than that evaluated by the composite method we suggest. The difference comes from the use, at step 1, of a graphic of ESWL increase, proposed by Epps and al., to evaluate the influence (Fi) of tire proximity instead of the use of the normalized deflection graphic proposed by Scala and Potter.

In our opinion, the way to evaluate this influence needs more research. Meanwhile, the method suggested gives results that adequately reflect the impact of this type of vehicle on Quebec roads.

5 EVALUATING THE COST OF THE PERMIT ACCORDING TO DAMAGE

The permit cost is calculated with a formula that takes into consideration the excess damage, the unit maintenance cost and the distance covered.

The excess damage is used to establish a more equitable rate setting. The damage caused by an extra-heavy vehicle is compared to the damage that a vehicle in conformity with the legal norms would cause by carrying the same load in more than one trip. The reference vehicle is loaded with the maximum legal load of 57 500 kg and its Passage Equivalency Factor (FEP) is evaluated at 5,5 (Figure 8).

The unit maintenance cost, wich is the cost inherent to the passage of a standard axle, has already been evaluated [11] for Quebec roads. Basically, the procedure used to evaluate this cost was to first calculate the intervention costs during the road lifetime, and then to find the approximate number of equivalency passages of the standard axle during this period.

Interventions on Quebec highways are spread over two 8-year cycles. After 50 years, reconstruction could be considered. On a sixteen-year basis, the global costs invested in the network will have been 230 000 $ per kilometre. Assuming that the climate is responsible for about 20 % of the damage on roads that are adequatly built and highly used such as highways, the cost of interventions due to traffic then becomes 184 000 $ per kilometre.

As for the cumulative equivalent standard axle passages, it is calculated from weigh-in-motion scales data. Taking into account the increasing rate of traffic over the last 16 years, we evaluate at about 19×10^6 the number of equivalent standard axle passages during this period.

The unit maintenance cost is then the ratio between these two parametres : (0,02 $/km/unit FEP) and (0,01 $/km/unit LEF).

The formula to evaluate the cost of the permit as a function of the damage is then as follows :

(4) $\text{Cost} = \left[\left(\text{FEP of studied vehicle} - (P \times 5{,}5) \right) \times \left(0{,}02\$/\text{km/unit FEP} \right) \times D \right]$

The first part of the equation is the calculation of the excess damage, "P" represents the number of trips that a vehicle in comformity with the legal norms would have to make to carry the same load. The second part represents the unit maintenance cost. The third part is the distance "D" in kilometres that the vehicle would have to cover.

Finally, on a short distance, the fee imposed to carriers could be too low to rationalize this type of transportation compared to the inconveniences it would cause. On a long distance, the cost could be too high and not compatible with the economy of the market. Minimum and maximum fees should then be considered.

5.1 EXAMPLES

We shall now examine three examples of permit cost calculation for three different configurations of vehicles. For each case, we also present the cost for two distances and two settings with two itineraries and two different periods of the year.

In the first example (Figure 9), a conventional vehicle has a gross vehicle weight of 73 800 kg. The owner must, however, request a single overload permit since the axial loads exceed the loads authorized by the Directive on special permits. In the first scenario, a haul on a highway during a normal period, would only cost the owner 0.89 $ to cover 10 km and 17.72 $ to cover 200 km. We can see the importance of establishing a minimum fee since the Ministry officials still had to do an itinerary study to deliver the permit. In a more critical scenario, in which the same load would be carried during the spring thaw, it would cost the owner 652 $ to cover 200 km.

In the second example (Figure 10), we calculate the cost of a permit for a mobile crane with a gross vehicle weight of 108 608 kg. From 7 $ on a highway during the normal period, the cost could be as high as 2 504 $ to cover 200 km on a provincial road during the spring thaw.

Finally, Figure 11 illustrates the third example. The vehicle is a low-bed multiaxle with a gross vehicle weight of 250 650 kg. For the same setting, the cost goes from 18 $ to cover 10 km on a highway during the normal period, to 6 289 $ to cover 200 km on a provincial highway during the spring thaw. For a very long distance, we can imagine that the cost would be prohibitive and that a maximum fee should be established to preserve the market.

6 CONCLUSION

The evaluation of the cost of a special overload permit proposed in this paper presents an interesting avenue to rationalize extra-heavy transports. We want to limit this type of transport because of the damage it causes to the pavement and works of art and because of the traffic disturbance and the special studies required of the Ministry officials. The formula is interesting because it is equitable since the damage that would be done by these vehicles is compared to the damage that would be done by vehicles in conformity with the norms carrying the same load in more than one trip.

The formula, once understood by industry, could be used to help manufacturers and carriers choose vehicles causing the least damage possible and, at the same time, it would reduce the cost of the permits.

Even if the approach to evaluate the damage is based on accepted scientific facts, it sometimes calls for some extrapolations. There still is a need for more studies concerning the impact of heavy vehicles. Research still have to be carried out, especially concerning the low-bed multiaxles' relative destructive effect on the pavement.

In this perspective, The Quebec Ministry of Transport is now looking at the possibility of establishing a permanent site for measuring the impact of heavy vehicles and assessing pavement performance.

Concerning the establishment of a new fee rate, we will first consult with industry to get their comments on the subject before any decision is made. This project is related to a reform that will facilitate the emitting of the special permits, delivered according to article 633 of the Highway Safety Code.

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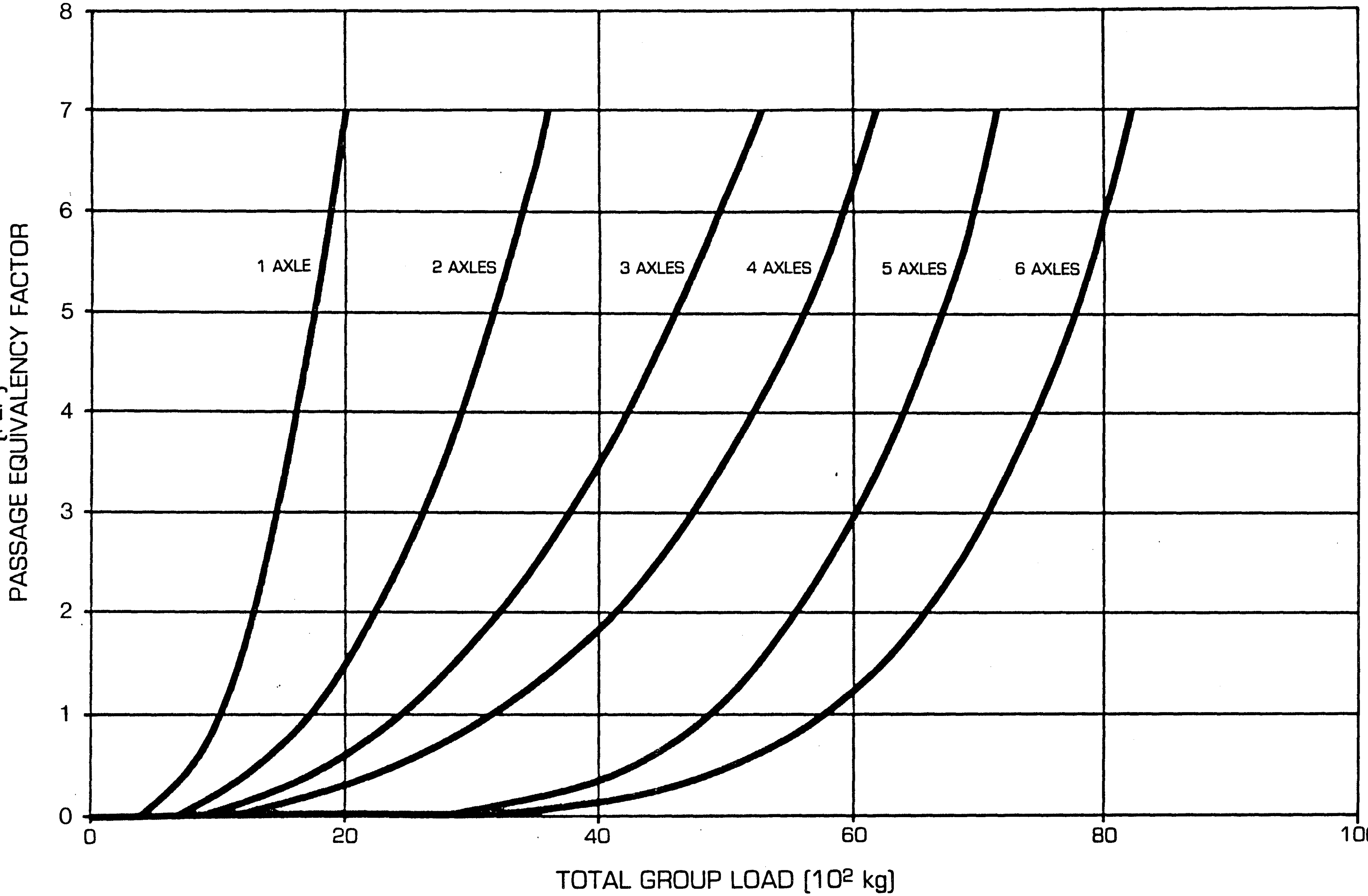
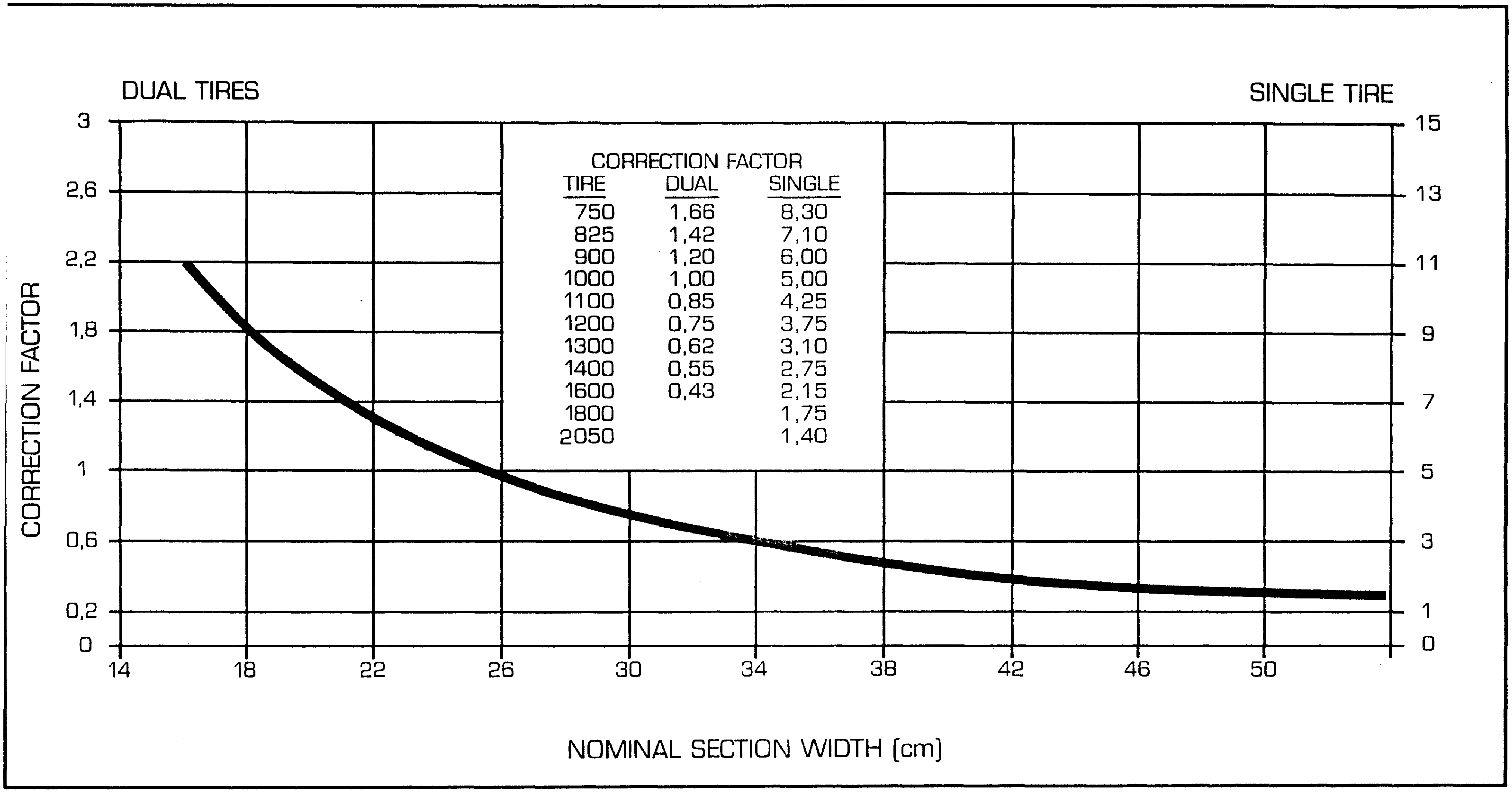


FIGURE 1: VARIATION OF PASSAGE EQUIVALENCY FACTOR [FEP] FOR SELECTED AXLE GROUPS AS LOAD ON AXLE GROUP IS CHANGED



CORRECTION FACTOR

TIRE	DUAL	SINGLE
750	1,66	8,30
825	1,42	7,10
900	1,20	6,00
1000	1,00	5,00
1100	0,85	4,25
1200	0,75	3,75
1300	0,62	3,10
1400	0,55	2,75
1600	0,43	2,15
1800		1,75
2050		1,40

FIGURE 2: EVALUATION OF CORRECTION FACTOR DEPENDING ON TIRE ARRANGEMENT AND TYPE

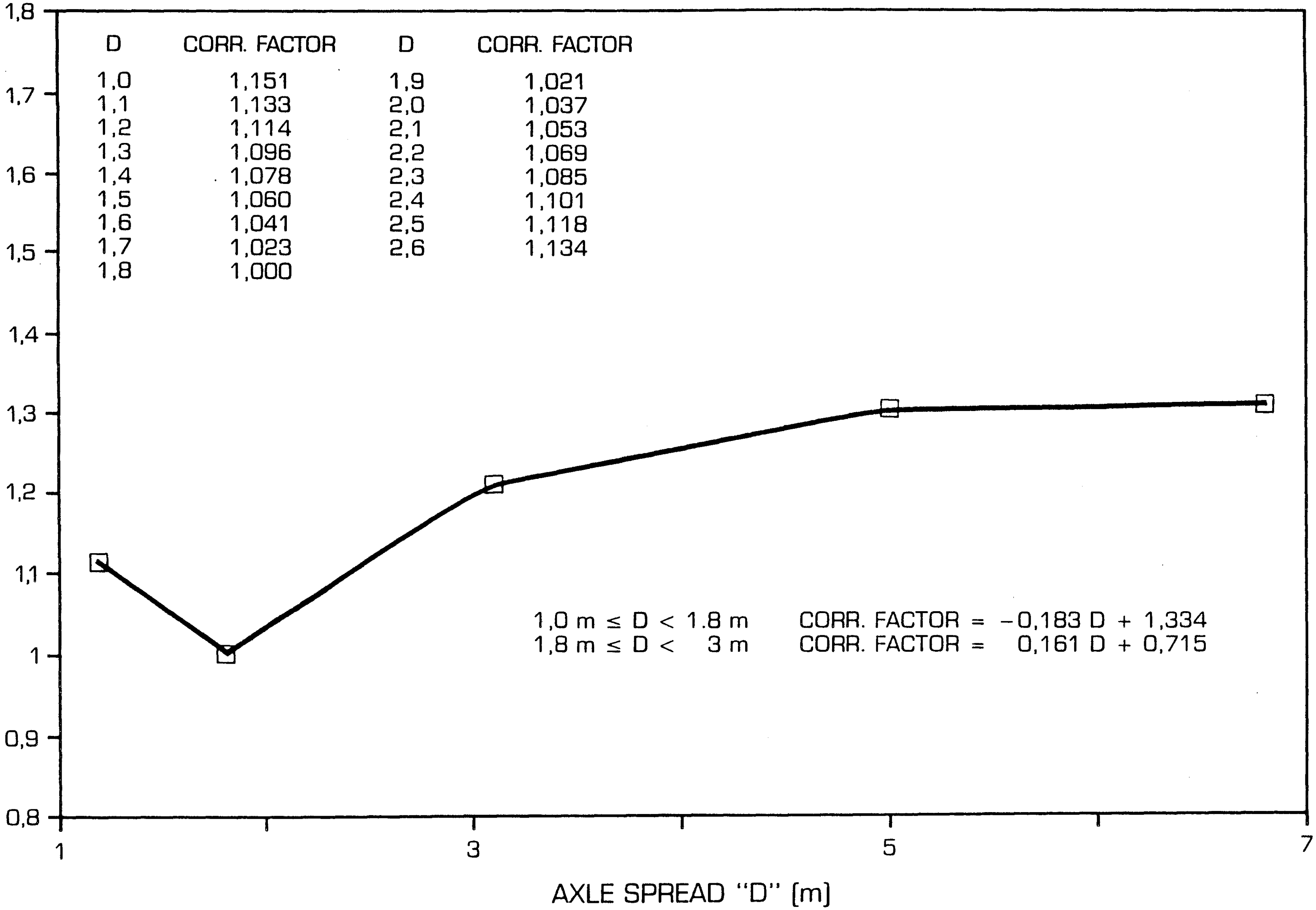


FIGURE 3: EVALUATION OF CORRECTION FACTOR DEPENDING ON AXLE SPREAD

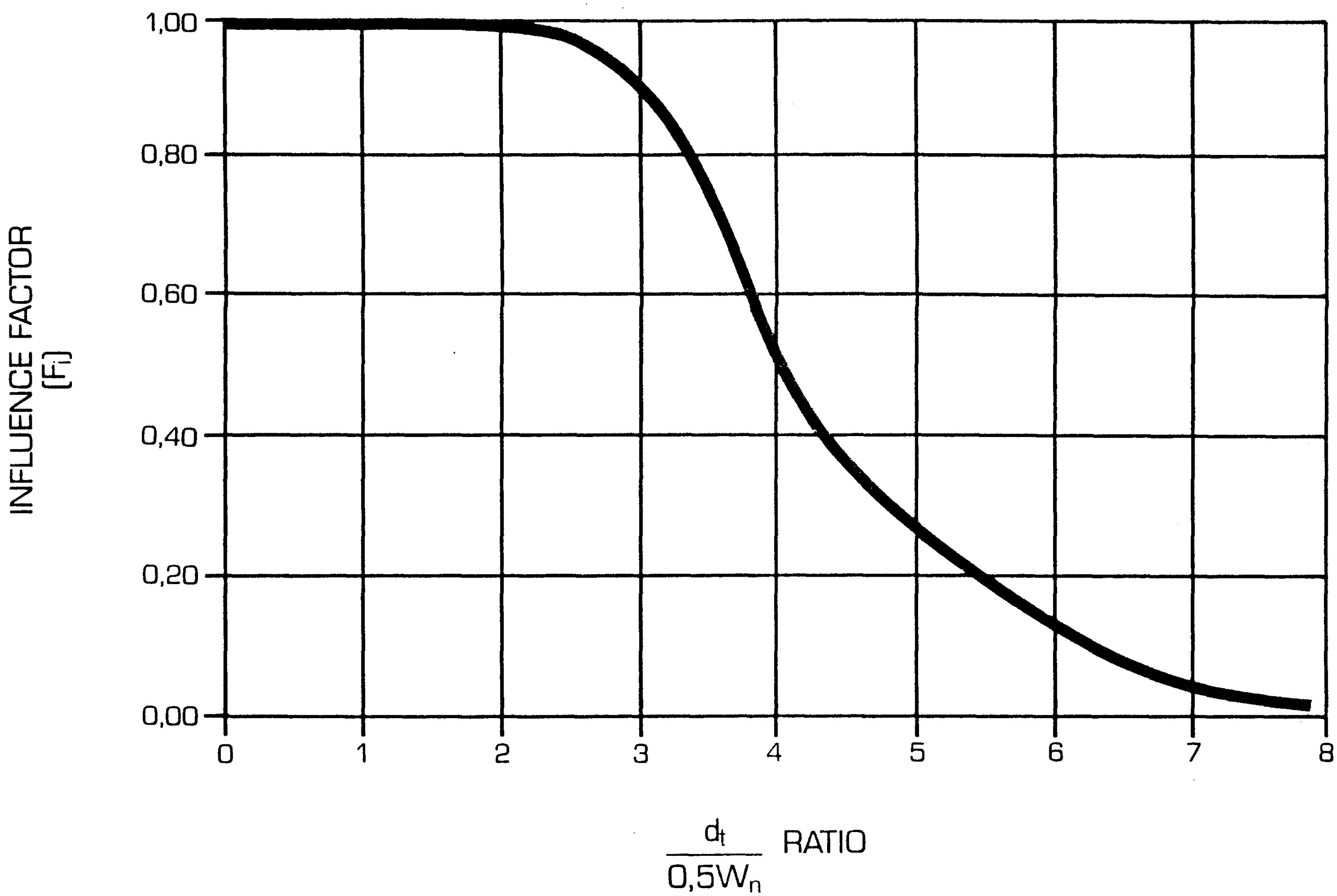
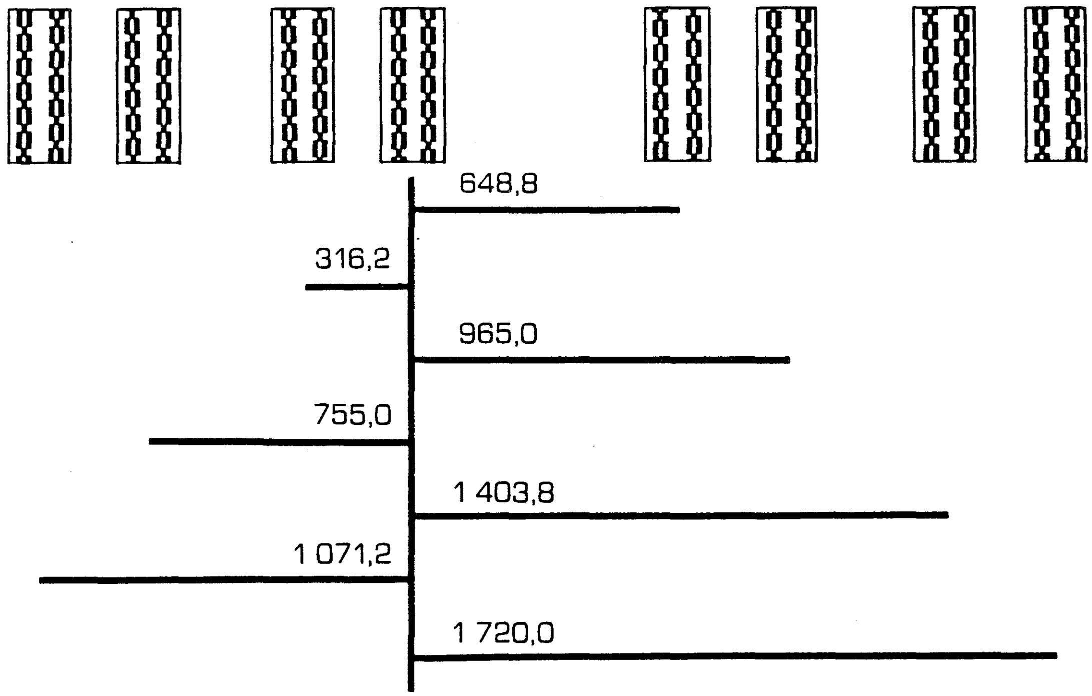


FIGURE 4: EVALUATION OF INFLUENCE FACTOR (F_i) TO CONSIDER TIRE NEARNESS.

(d_t = DISTANCE FROM CENTRE OF TIRE;
$0{,}5W_n$ = HALF NOMINAL SECTION WIDTH)
(AFTER EPPS ET AL. [11])

TYRE TYPE
7,50 × 15

DISTANCE FROM CENTER OF TIRE (mm)



$$\frac{d_t}{.5W_n} \text{ RATIO} = \frac{1\,071{,}2}{95{,}3} \quad \frac{755{,}0}{95{,}3} \quad \frac{316{,}2}{95{,}3} \quad \frac{0{,}0}{95{,}3} \quad \frac{648{,}8}{95{,}3} \quad \frac{965{,}0}{95{,}3} \quad \frac{1\,403{,}8}{95{,}3} \quad \frac{1\,720{,}0}{95{,}3}$$

=	9,74	6,86	2,87	0,0	5,90	8,77	12,76	15,64
F_i (see fig. 4) =	0	0	0,80	1	0,04	0	0	0

ΣF_i = 1,84

FIGURE 5: EXAMPLE OF EVALUATION OF THE INFLUENCE FACTOR (F_i)

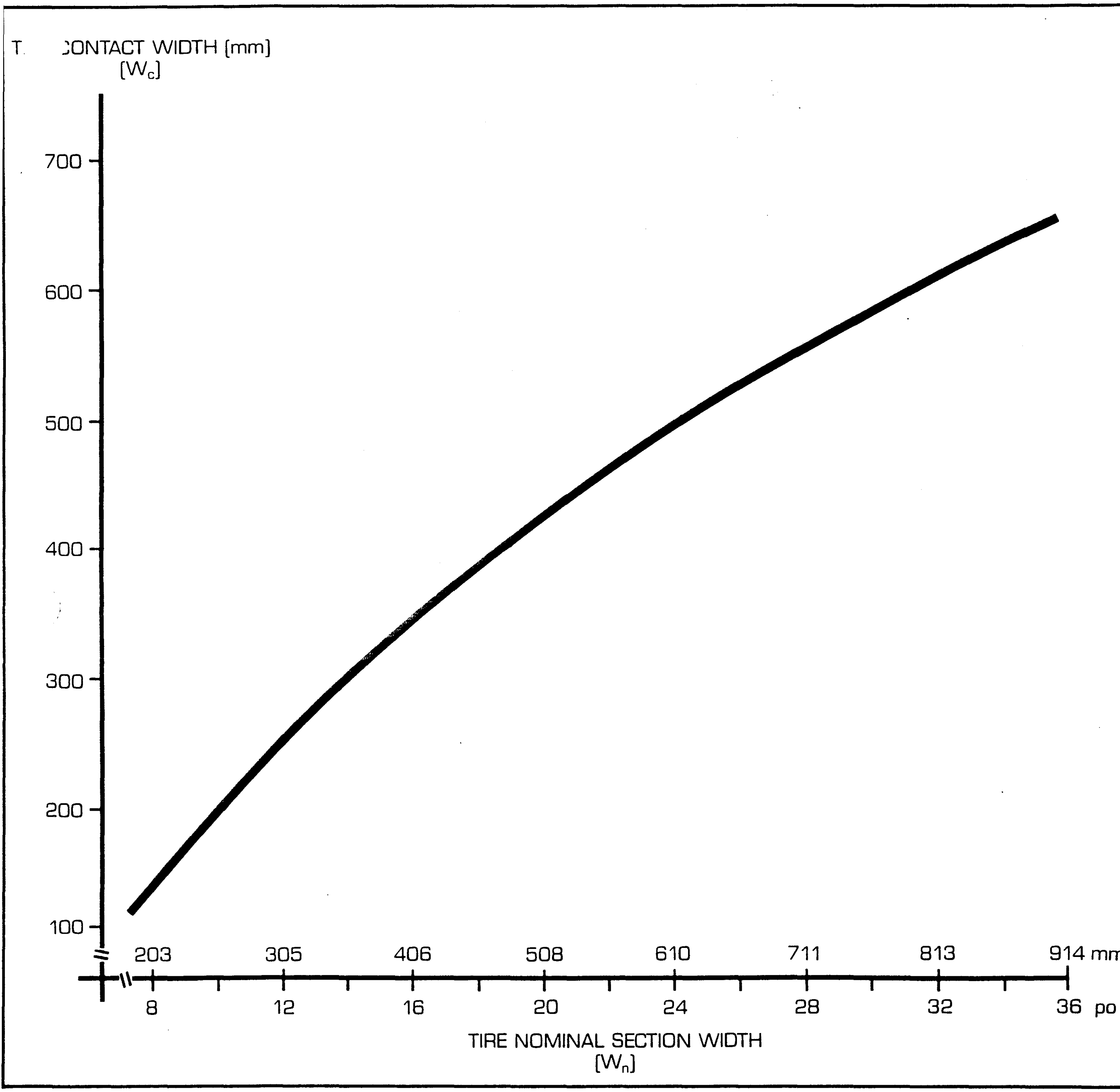


FIGURE 6: RELATION BETWEEN TIRE CONTACT WIDTH AND TIRE NOMINAL SECTION WIDTH

(AFTER SCALA AND POTTER [10])

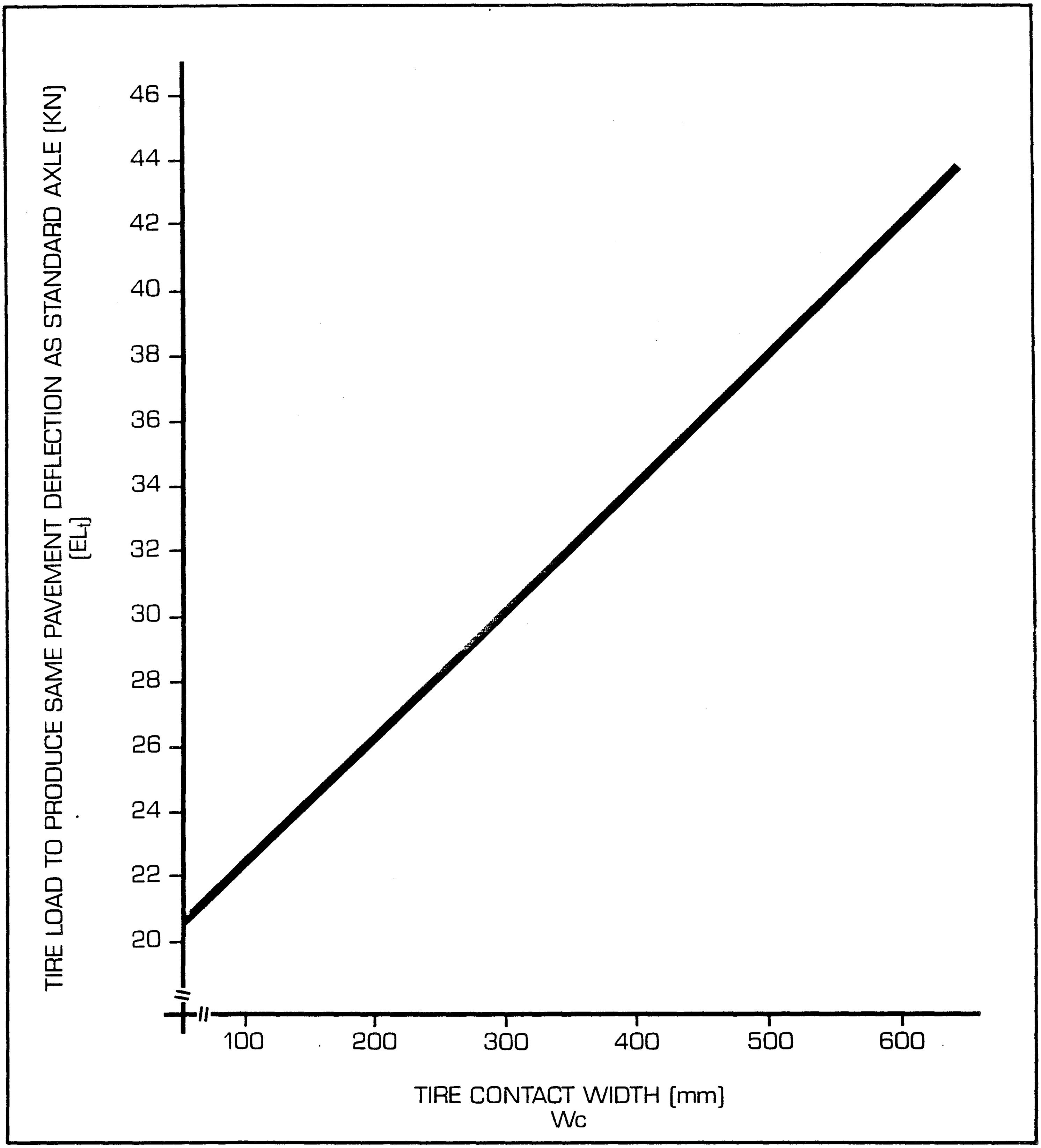
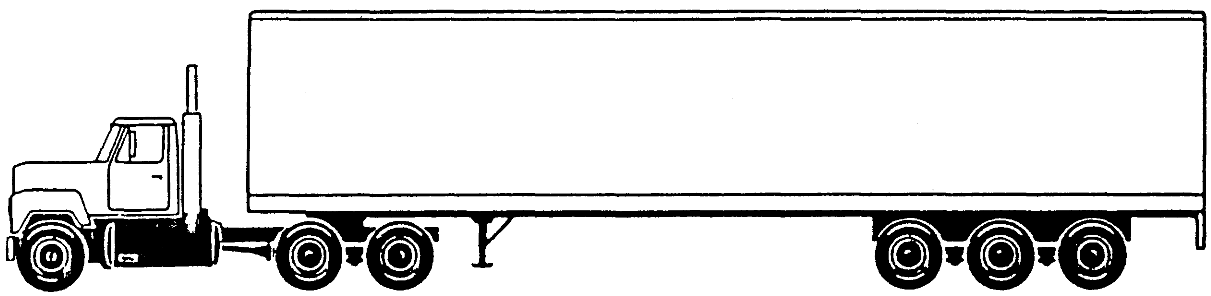


FIGURE 7: RELATION BETWEEN TIRE LOAD TO PRODUCE SAME DEFLECTION AS THE STANDARD AXLE AND TIRE CONTACT WIDTH.

[AFTER SCALA AND POTTER [10]]



GROSS COMBINATION WEIGHT: 57 500 kg

PAYLOAD: 37 800 kg

PASSAGE EQUIVALENCY FACTOR (FEP): 5,5

FIGURE 8: CHARACTERISTICS OF THE TRUCK USED AS REFERENCE FOR THE EVALUATION OF EXCESS DAMAGE

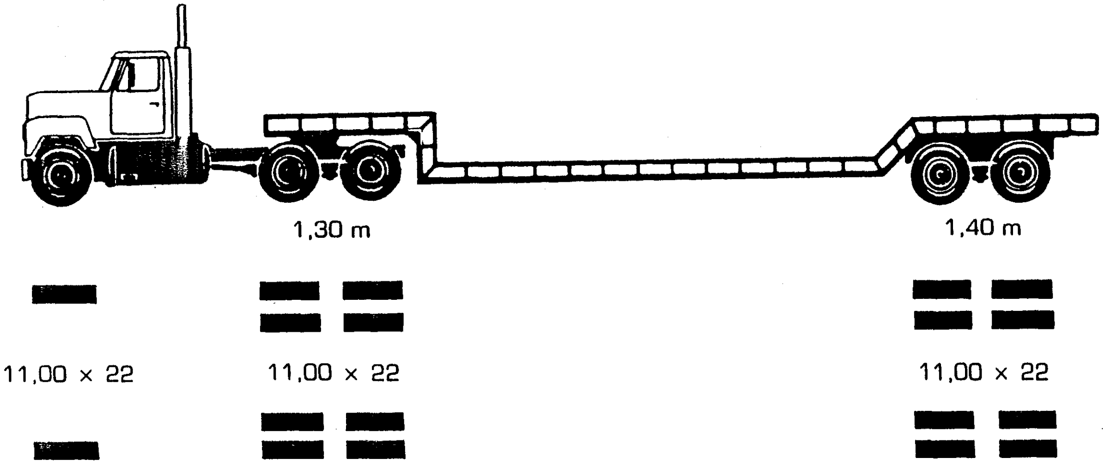
GROSS COMBINATION WEIGHT

73 800 KG

EMPTY WEIGHT

19 700 KG

SA : Single axle
TT : Tractor tandem axle
ST : Semitrailer tandem axle



						SCENARIO 1			**SCENARIO 2**		
						HIGHWAY NORMAL PERIOD			PROVINCIAL ROAD THAW		
AXLE	LOAD (KG)	FEP	TIRE CORRECTION	AXLE SPREAD CORRECTION	SUB TOTAL	ROAD CORRECTION	PERIOD CORRECTION	TOTAL	ROAD CORRECTION	PERIOD CORRECTION	TOTAL
SA	7 200	0,396	4,25	—	1,683	1,0	1,0	1,683	1,85	7,5	23,352
TT	32 400	5,349	0,85	1,096	4,983	1,0	1,0	4,983	1,85	7,5	69,139
ST	34 200	6,156	0,85	1,078	5,641	1,0	1,0	5,641	1,85	7,5	78,269
CORRECTED FEP								12,307			170,760
COST FOR 10 KM 200 KM								$ 0,89 $ 17,72			$ 32,58 $ 651,56

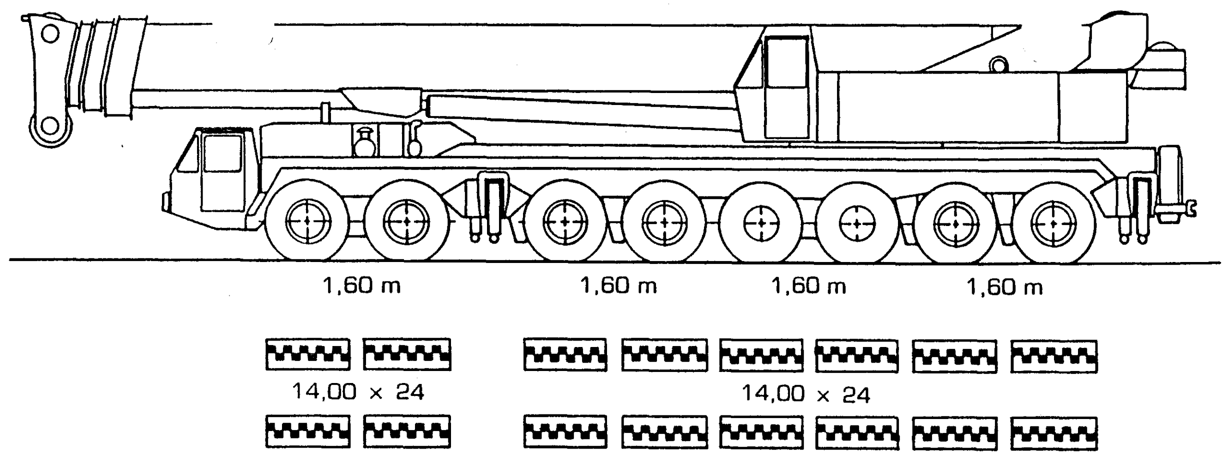
GURE 9: EXAMPLE OF COST PERMIT EVA ATION FOR A CONVENTIONAL TYPE TRUC

LIEBHERR LT 1200 CRANE

GROSS VEHICULE WEIGHT

108 608 KG

FT : Front tandem axle
OA: 6 other axles



						SCENARIO 1			SCENARIO 2		
						HIGHWAY NORMAL PERIOD			PROVINCIAL ROAD THAW		
AXLE	LOAD (KG)	FEP	TIRE CORRECTION	AXLE SPREAD CORRECTION	SUB TOTAL	ROAD CORRECTION	PERIOD CORRECTION	TOTAL	ROAD CORRECTION	PERIOD CORRECTION	TOTAL
FT	27 157	3,379	2,75	1,041	9,673	1,0	1,0	9,673	1,85	7,5	134,213
OA	81 471	12,643	2,75	1,041	36,194	1,0	1,0	36,194	1,85	7,5	502,188
CORRECTED FEP								45,867			636,401
COST FOR 10 KM 200 KM								$ 7,10 $ 141,90			$ 125,20 $2 504,00

FIGURE 10: EXAMPLE OF COST PERMIT EVALUATION FOR A MOBILE CRANE.

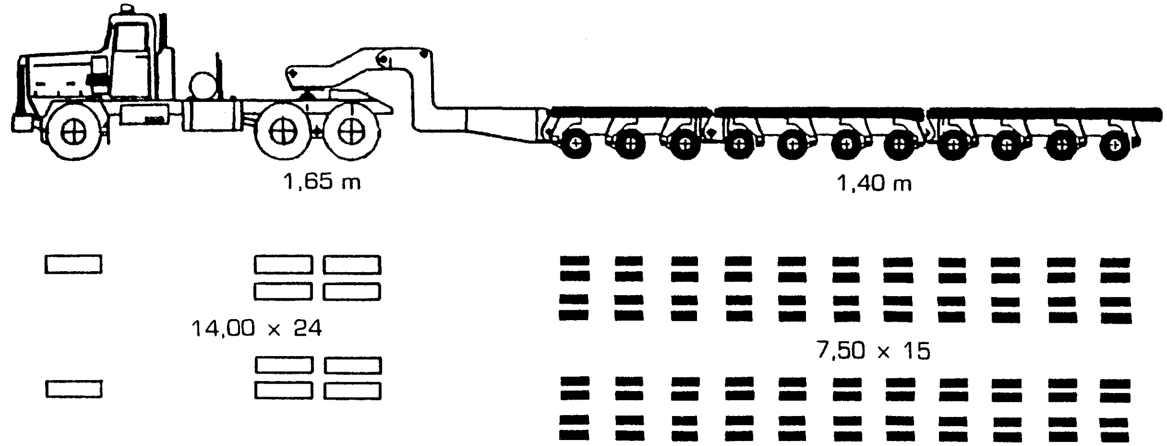
GROSS COMBINATION WEIGHT

250 000 KG

EMPTY WEIGHT

77 000 KG

SA : Single axle
TT : Tractor tandem axle
MA : Multiaxles 1) one axle
2) total



						SCENARIO 1			SCENARIO 2		
						HIGHWAY NORMAL PERIOD			PROVINCIAL ROAD THAW		
AXLE	LOAD (KG)	FEP	TIRE CORRECTION	AXLE SPREAD CORRECTION	SUB TOTAL	ROAD CORRECTION	PERIOD CORRECTION	TOTAL	ROAD CORRECTION	PERIOD CORRECTION	TOTAL
SA	9 100	0,767	2,75	—	2,109	1,0	1,0	2,109	1,85	7,5	29,266
TT	24 850	2,683	0,55	1,032	1,523	1,0	1,0	1,523	1,85	7,5	21,130
MA 1)	19 700	9,403	—	—	—	—	—	—	—	—	—
MA 2)	216 700	103,433	—	1,078	111,501	1,0	1,0	111,501	1,85	7,5	1 547,073
CORRECTED FEP								115,133			1 597,469
COST FOR 10 KM 200 KM								$ 17,97 $ 359,46			$ 314,44 $ 6 288,81

FIGURE 11 : EXAMPLE OF COST PERM. EVALUATION FOR A LOW-BED MULTIAXLES.

TABLE 1 EVALUATION OF CORRECTION FACTOR TO CONSIDER ROAD CATEGORY

CATEGORY	CORRECTION FACTOR
HIGHWAY	1,00
PROVINCIAL ROAD	1,85
REGIONAL ROAD	2,94
LOCAL ROAD	10,38

TABLE 2 EVALUATION OF CORRECTION FACTOR TO CONSIDER THAW PERIOD

CATEGORY	CORRECTION FACTOR
HIGHWAY	5,0
PROVINCIAL ROAD	7,5
REGIONAL ROAD	7,5
LOCAL ROAD	10,0

SESSION 8 – HIGHWAY GEOMETRICS AND OPERATIONS

Chairman: John Robinson, University of New Brunswick

Speakers

1. **Designing the Highway System to Accommodate Very Large Trucks**
   A.D. Cherwenuk, Alberta Transportation and Utilities

2. **Road and/or Transport Productivity**
   K. Heald, Western Highway Institute, California

3. **Analysis of Traffic Operations for the Movement of Very Large Vehicles on the High-Wide Corridor Between Edmonton and Ft. McMurray**
   J. Morrall, University of Calgary; A. Werner, Alberta Transportation and Utilities