TOWARDS RATIONAL VEHICLE WEIGHT CONTROL IN TRINDAD AND TOBAGO

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ABSTRACT

Special permits are required for the transportation of large indivisible loads or heavy construction equipment whenever these loads exceed the legal limits in Trinidad and Tobago. Such permits should only be issued after careful consideration of the likely damage to the stock of highway bridges and flexible pavements. However the regulatory agency, the Transport Board, has not published any guidelines for the benefit of prospective applicants.

In this paper a critical review of the Motor Vehicle Ordinance and Regulations is made. It is shown inter alia that the existing distribution of vehicle weight formula, the so-called bridge formula, is quite meaningless. A new formula which links bridge strength with allowable weight is proposed. This formula can be used to quickly evaluate permit applications. Typical cases, which have been taken from the records of the Transport Board, are also presented.

1.0 INTRODUCTION

At present, in Trinidad and Tobago, there is no clear relationship between the loads which are used to design bridges and pavements and the vehicle weight regulations. As a result the legal maximum gross vehicle weight is unusually low, 15 240kg (15 tons). Consequently any load which is in excess of this value must first be evaluated by the Transport Board before a permit can be issued. This is usually a slow and time-consuming process.

The purpose of this paper is to develop guidelines for the rapid evaluation of permit applications. This has been achieved, largely, by the development of a bridge formula that is safe yet not restrictive. The influence of the increased allowable loads on pavement damage caused by fatigue is also discussed. It is anticipated that pavement strength and life will not be significantly affected.

2.0 REVIEW OF LEGISLATION

Section 12.(1) of the Motor Vehicle and Road Traffic Ordinance [1] was amended by Act No.31 of 1976 to read as follows:

12.(1) Save as hereinafter in this section

(a) no motor vehicle exceeding the maximum gross weight of ***fifteen tons***;

(b) no trailer exceeding the maximum gross weight of ***eight tons***;

(c) no motor vehicle or trailer all the wheels of which are not fitted with pneumatic tyres shall be used upon any road, and no licence shall be issue in respect thereof.

It is easy to appreciate how restrictive this law is if one considers the case of an ordinary readymix concrete truck which weighs approximately 24t, and therefore must be referred for special overload evaluation.

Additional laws relating to vehicle dimensions and distribution of weight are set forth in Section 28 of Motor Vehicle and Traffic Regulations [2]. Amongst these the most important are as follows:

28.(c) (i) no motor vehicle constructed for the carriage of passengers only shall exceed ten metres in overall length, except trolley buses operated by the Port-of-Spain Corporation which may be of an overall length not exceeding ten metres. No other motor vehicle shall exceed nine metres in overall length;

(ii) no trailer other than a semi-trailer shall exceed seven metres in overall length;

(iii) no other motor vehicle and semi-trailer attached shall exceed eleven metres in overall length;

(iv) no motor vehicle and trailer attached shall exceed fourteen metres in overall length; provided that the overall length of a motor vehicle and pole trailer carrying pipes may extend to fifteen and a half metres and of an agricultural tractor drawing two trailers to seventeen metres;

28.(e) (i) the total weight transmitted to the road surface by the wheels of any one axle of a motor vehicle or trailer shall not exceed eight tonnes;

(ii) the combined gross weights of a motor vehicle and trailers shall not exceed the weight arrived by the formula ***'eight thousand one hundred and sixty-five kilograms + (L x 800)'*** where L is the length in millimetres measured from the front wheels to the centre of the rearmost wheels of the vehicle or combination of vehicles;

(iii) for the purpose of this paragraph two or

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Pertinent discussion will be published in July 1994 West Indian Journal of Engineering if received by

more axles in line transversely and two or more axles the distance between the centre lines of which is less than one and three-tenths metres shall be deemed to be a single axle;

Some of the dimensional requirements are shown in Fig.1.

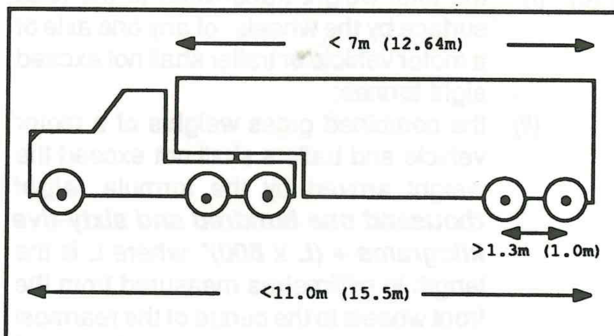
The National Transportation Study [3] has pointed out that about 50 000 containers conforming to international standards (ISO) could not be moved without special permits allowing the regulation dimensions to be exceeded. In light of this the study went on to recommend several changes to the existing regulations, see Fig.1.

It is clear that by limiting a single axle weight to 8 000kg, which is approximately equal to the weight of a standard axle, 8 200kg, the existing regulations have been guided by considerations of pavement life and strength. These considerations are also evident in 28(e) where an axle pair whose centreline distance apart is less than 1.3m is treated as a single axle. However modern empirical and analytical flexible pavement design methods [4,5,6] recognize that:

- heavier axle loads can be carried by using dual tyre single axles or groups of axles to spread the load
- higher tyre pressure increases pavement deterioration
- single tyre steering axle damage factors are significantly higher than those of other axles.

All of these factors have been taken into account by the National Transportation Study which recommends that the existing weight and dimension regulations should be revised. A more comprehensive set of regulations, which is intended to permit operators to increase payloads by choosing the appropriate equipment, was proposed as follows:

- maximum single tyre axle weight of 8 200kg
- maximum dual tyre weight of 9 000kg



* Values in parentheses refer to those recommended by the National Transportation Study

Fig. 1 Typical dimensions governing regulations

- maximum dual tyre tandem axle weight of
  15 400kg for axle spacing of 1.0m - <1.2m
  16 800kg do. 1.2m - <1.3m
  17 200kg do. 1.3m - <1.4m
  17 500kg do. 1.4m - <1.5m
  17 900kg do. >1.5m
- for tyres less than 150mm in width, the maximum contact pressure must not exceed 9kg/mm of tyre width; for tyres greater than 150mm in width the maximum contact pressure must not exceed 11kg/mm.
- maximum weight on a front axle of 4 000kg up to a maximum of 6 000kg subject to manufacturer's specifications.

A major defect in the existing regulations is the highly inaccurate bridge formula , '8 165kg + L x 800'. If one substitutes a value of 1000mm for L then one obtains the absurdly high value of 808 165kg for the permissible weight of a pair of axles. In fact officials of the Transport Division have indicated that the formula is never used because of its obvious incorrectness. The development of a more realistic formula will be considered in the next section.

3.0 PROPOSED BRIDGE FORMULA

In order to derive a new bridge formula a convenient starting point is the assumption that nearly all the bridges, which lie on the network of roads maintained by the Ministry of Works, can now safely withstand type HA loading in accordance with BS 153:Part 3A [7]. This level of loading, or its equivalent, is the lowest that is specified by the Ministry of Works for the bridges that fall within its jurisdiction. It should be noted that BS 153:Part 3A was replaced in 1978 by BS 5400:Part 2 [8] in which HA loading was retained with some minor amendments and presented in a limit state format.

An obvious built-in limitation of the above assumption is that annual permits, which are to be issued on the basis of any such formula, should not only specify the weight limit but the appropriate schedule of roads. Another limitation is that the load-carrying assessment is purely theoretical. And so any new formula should, as far as possible, reflect the practice of the Transport Board, since the continued satisfactory performance of the existing bridges suggests that prevailing legal overweight loads are not excessive. This latter consideration is of some importance since, in Trinidad, thorough bridge evaluation is hardly ever carried out and sub-standard bridges are very rarely posted.

The basis for HA loading has been discussed by Henderson [9]. For loaded lengths up to 30m the loading approximately represents the effects of closely spaced vehicles of 24t laden weight in each of two traffic lanes. This loading can also be represented by a lane load of 30kN/m along the full portion of the influence line, plus a knife edge load of 120kN that can be placed anywhere along the span. For loaded lengths greater than 30m the lane load is less than the above value because the spacing between vehicles is progressively increased and medium weight vehicles of 10t and 5t are interspersed. The application of a single wheel load of 100kN is also provided for, where a member supports a small area of roadway, such that it may be called to to carry the weight of one or two wheels, and where the proportion of lane load and knife edge load which would be allocated to it is small.

A dynamic allowance of 25% on one axle or pair of adjacent wheels was included in deriving HA loading. This is considered an adequate allowance for conditions such as prevail in Great Britain. However, other investigations [10] seem to indicate that a more realistic allowance is made up of two parts, 10% for the uniformly distributed lane load and 40% for the axle load. And these latter values will be adopted, where necessary, in subsequent calculations.

In order to proceed, HA loading for simple spans up to 30m is selected as a direct measure of the maximum permissible gross weight, W, of a vehicle. This span range has been selected because, as stated before, it can be fully loaded with a convoy of 24t trucks. It is easy to see that the wheel base, in metres, times the lane load (30kN/m) plus the axle load (120kN) gives a crude estimate of the maximum permissible gross weight, W, of a vehicle. It should be noted that this takes account of the clearance of 2.134m(7ft) between vehicles, centre-to-centre of wheels, assumed by Henderson [9]. We can refine this calculation by introducing the equivalent base length' concept of Csagoly and Dorton [11].

The equivalent base length, B_m, is defined as the length over which the weight of a vehicle should be uniformly distributed in order to cause load effects in a bridge similar to those causedby the the vehicle itself, see Fig. 2. It is determined by the following equation

$$B_m = \frac{4\Sigma|W_i x_i|}{W} - \frac{2(N-1)}{bN}\left[\frac{\Sigma W_i x_i}{W}\right]^2 \qquad (3.1)$$

where
b is the distance between first and rearmost axles (m)
W_i is the load on the i-th axle (kg)
W is the total load (kg)
x_i is the distance of the i-th axle from the axle closest to the centre of gravity of the group of axles (m)
N is the number of axles.

By using the equivalent base length instead of the

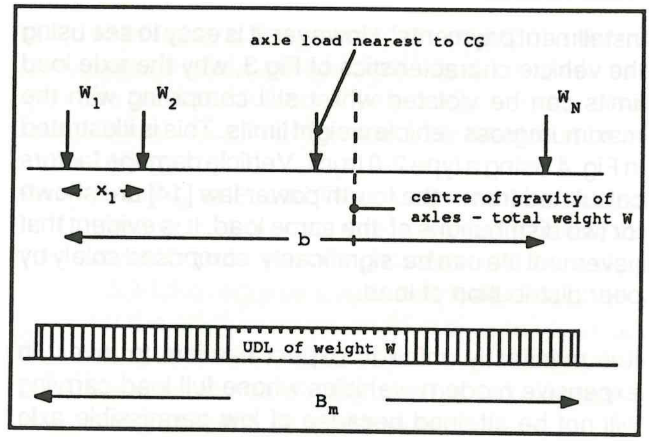


Fig. 2 Equivalent base length

wheel base length and taking into account impact we can now write the following equation

$$W \ngtr 30B_m/1.1 + 120/1.4 \quad \text{(kN)}$$

$$\text{or } W \ngtr 2780B_m + 8740 \quad \text{(kg)} \qquad (3.2)$$

This is the proposed bridge formula which considers not only the gross vehicle weight but its distribution on the axles and the interaxle spacing. Any number of vehicles complying with this formula can be allowed on a bridge.

It may happen that only a single axle or group of axles may fit on a lane of a bridge at a given time. In this case the HA wheel load of 100 kN must be considered as providing a minimum level of loading. This implies that for groups of three or more axles the axle weight must be reduced. For example, in the case of a three-axle set, the maximum axle weight should be not greater than 6625 kg (65kN)

4.0 VEHICLE CHARACTERISTICS

An analysis of the records for the period 1980 -1983 of the Transport Division has shown that the most significant types of heavy vehicle configuration are those shown in Fig.3. The average maximum gross weight and axle load distribution refer to those stated in the manufacturer's specifications The data shows good correlation with actual traffic characteristics from other countries [12]. Table 1 [13] gives the average distribution of truck types: light, medium, and heavy.

The National Transportation Study reported an appreciable incidence of overloading (>8 000kg) in its axle load survey. Charles [13] in discussing these results concluded that 'the prime reasons for such extensive overloading are excessive payload (not improper distribution) and the cost to meet high vehicle installment payments'. However, it is easy to see using the vehicle characteristics of Fig 3, why the axle load limits can be violated whilst still complying with the maximum gross vehicle weight limits. This is illustrated in Fig. 4 using a type 2-0 truck. Vehicle damage factors calculated from the fourth power law [14] are shown for two distributions of the same load. It is evident that pavement life can be significanty comprised solely by poor distribution of load.

It is manifestly unfair to expect hauliers to invest in expensive modern vehicles whose full load-carrying will not be attained because of low permissible axle loads. It would make much more economic sense to issue permits allowing heavier axle loads. A value of 10 500kg per dual tyre axle appears to be an acceptable upper limit for annual permits based on the current practice of the Transport Board in dealing with very heavy vehicles (> 3 axles).

TABLE 1

COMMERCIAL TRAFFIC COMPOSITION [13]

Load Clas	Type	%Trucks
Light-two axles, single tyres	Rigid	25.5
Medium - two axles, dual rear tyres	Rigid	64.8
Heavy - three or more axles	Rigid, articulated	9.7

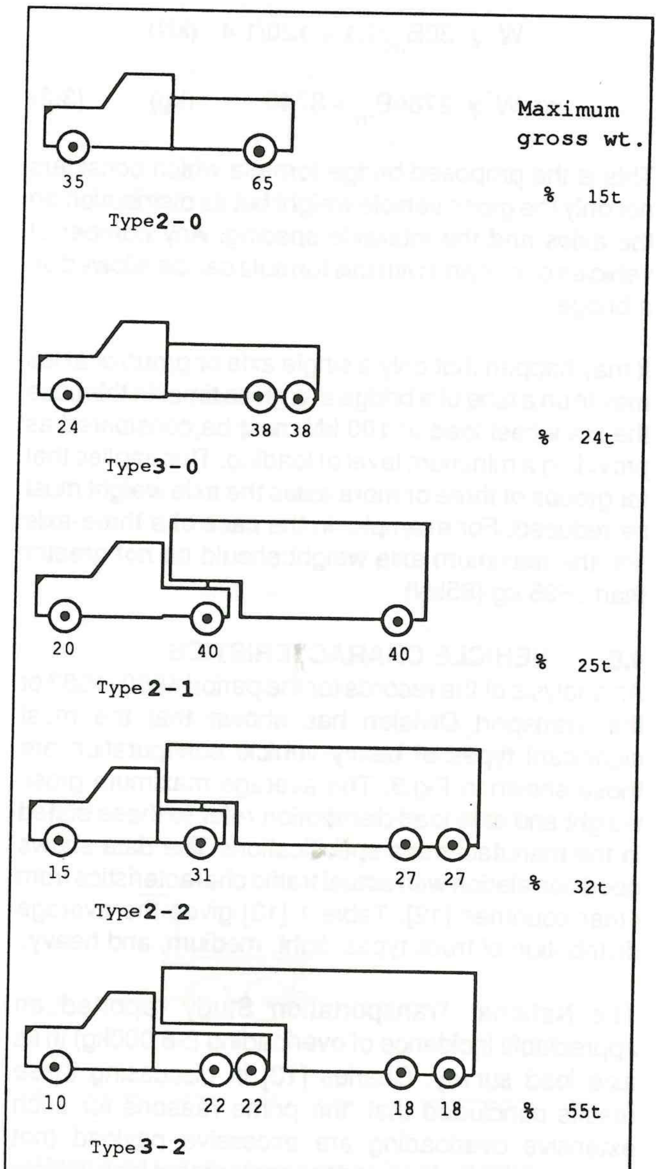


Fig. 3 Typical truck characteristics

5.0 WEIGHT CONTROL USING THE PROPOSED FORMULA

The procedure for evaluating permit applications will now be illustrated using examples taken from the records of the Transport Board. It will be seen that the proposed bridge formula provides maximum gross

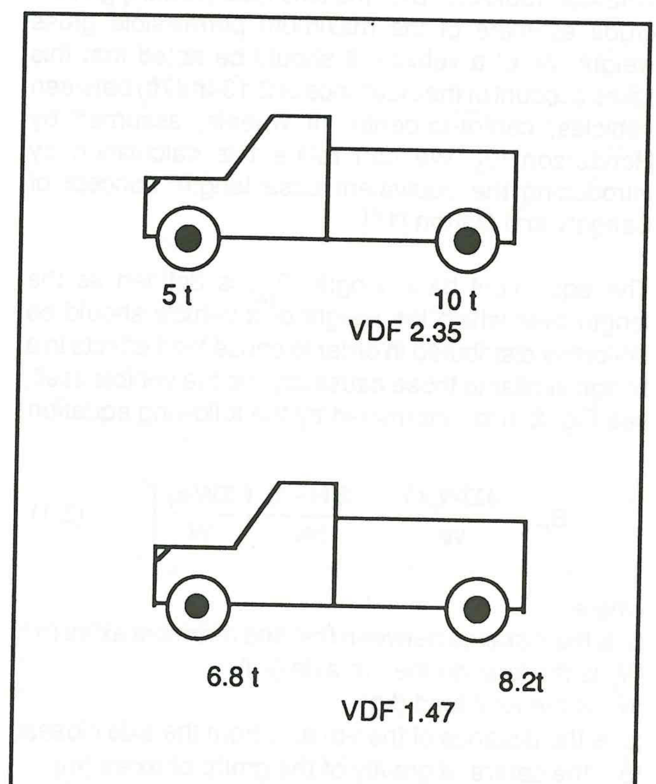


Fig. 4 Vehicle damage factors (VDF) for trucks of same weight

vehicle weights which are in general reasonably close to those allowed by the Transport Board.
Example 1.

A concrete truck is shown in Fig. 5, below. Using the formula

6 000 ⬇ 10 100 ⬇ 10 100 ⬇ (kg)

3865 1270 (mm)

Fig. 5

we get a permissible gross vehicle weight of 23 91kg. The approved weight limit was 23 730kg.

Example 2.
A truck and dump trailer combination is shown in Fig.6, below. In this case the formula gives an allowable weight of 36 990kg

4450 ⬇ 7655 ⬇ 7655 ⬇ 10540 ⬇ 10540 ⬇ (kg)

3700 1300 2800 1360 (mm)

Fig. 6

which is approximately 10% less than the actual approved value of 40 845kg.

Example 3.
A truck and trailer (type 3-2) used for the transportation of bulk cement is shown in Fig.7. The formula allows a maximum

6000 ⬇ 9230 ⬇ 9230 ⬇ 9640 ⬇ 9640 ⬇ (kg)

3700 1270 7210 1270 (mm)

Fig. 7

weight of 55 675kg. The Board did in fact approve the full requested load of 43 740kg. It should be noted that axle load restrictions rather than the formula determine the maximum permissible laden weight of this particular vehicle.

The foregoing examples show that the proposed bridge formula together with appropriate axle load limits provide a convenient means of rapidly evaluating permit vehicles.

6.0 CONCLUSIONS

Several important points emerge from this study:

1. The proposed bridge formula provides a direct relationship between bridge design loads (HA loading) and the permissible weight of a permit vehicle. Vehicles which satisfy the formula can be allowed to use these bridges freely even though they might exceed the legal limit of 15 240 kg.
2. Existing axle load limits unnecessarily restrict maximum gross vehicle weights. Indeed, the most commonly used 2-axle truck of laden weight 15 240kg requires a rear axle load of 10 000kg for the efficient transportation of its full payload.
3. Long term axle load surveys must be undertaken in order to realistically assess the damaging effect of traffic on pavements.
4. The guidelines developed in this paper allow the haulier a great deal of flexibility in the selection of appropriate vehicles. Evaluation is quick and straightforward.
5. All sub-standard bridges will have to be posted before annual overload permits can be routinely issued. Otherwise routes will have to be specified.

It is to be noted that only single-trip permits should be issued to exceptionally heavy vehicles, i.e. those which do not conform to the proposed bridge formula.For such applications a detailed route evaluation will have to be performed.

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