SPEED OF OVERWEIGHT VEHICLES

Transit New Zealand Research Report No. 30

SPEED OF OVERWEIGHT VEHICLES

WORKS CONSULTANCY SERVICES Ltd,
Wellington, New Zealand

Transit New Zealand Research Report No. 30

ISBN 0-478-04117-9
ISSN 1170-9405

P O Box 5084, Lambton Quay, Wellington, New Zealand
Telephone (04) 499-6600; Facsimile (04) 499-6666

Works Consultancy Services Ltd. 1994. Speed of overweight vehicles. *Transit New Zealand Research Report No. 30.* 18pp.

Keywords: bridges, impacts, Impact Factor, mobile cranes, overloads, transporters, overweight vehicles, vehicle speed

AN IMPORTANT NOTE FOR THE READER

CONTENTS

EXECUTIVE SUMMARY 6
ABSTRACT 7

1. INTRODUCTION 7

2. LITERATURE SEARCH 7
2.1 Aves (1972) 8
2.2 Page (1976) 11
2.3 Rambhai (1980) 11
2.4 Thurston (1983) 11
2.5 Billing and Green (1984) 14
2.6 Melcer (1988) 15
2.7 Haijan (1989) 15
2.8 Other Work 15

3. CONCLUSIONS 16
3.1 General 16
3.2 Highway Permits 16
3.3 Further Work 17

4. REFERENCES 18

EXECUTIVE SUMMARY

The transport industry in New Zealand has requested that the maximum speed of transporters and mobile power cranes be increased from the present 50 km/h to the legal speed limit of 100 km/h.

In response to this request, a literature search of investigations of possible relationships between speed of overweight vehicles and their impact at higher speeds on pavements and bridges was made. Typical data are shown as diagrams, on which is superimposed the effect of the suggested increase in Impact Factor to be used for issuing overweight permits. They show a relationship that is discernible but not easily quantifiable.

An increase of 10% to the Impact Factor currently used is considered reasonable to compensate for an increase in speed to 100 km/h for transporters and mobile cranes.

Modification of the Highway Permits program to implement the proposed 10% increase to the Impact Factor for transporters and mobile cranes is suggested. The simpler alternative of applying the increase to all overweight vehicles is also given for comparison.

ABSTRACT

The transport industry in New Zealand has requested that the maximum speed of transporters and mobile power cranes be increased from the present 50 km/h to the legal speed limit of 100 km/h.

In response to this request, a literature search of investigations of possible relationships between speed of overweight vehicles and their impact at higher speeds on pavements and bridges was made and is reported.

Modification of the Highway Permits program to implement a proposed 10% increase to the Impact Factor for transporters and mobile cranes is suggested.

1. INTRODUCTION

The Transit New Zealand Overweight Policy at present specifies that the maximum speed of any vehicle travelling under permit is 50 km/h. The transport industry has made representations to Transit New Zealand requesting that the limit be removed for transporters and mobile power cranes, and that they be allowed to travel at legal highway speed. The reasoning is that such vehicles are designed to travel at that speed, and that the only consideration is protection of pavements and bridges.

The objective of this study was to determine if the maximum speed of transporters travelling with overweight permits could be increased from the present 50 km/h to the legal speed limit, and if any action would be necessary to allow this.

The method was to determine whether a recognised relationship exists between speed and Impact Factor of overweight vehicles on pavements and bridges and, if any exists, whether the Highway Permits program could be altered to take account of it.

Impact Factor is defined as the ratio of the maximum dynamic load effect of a vehicle, during a loading event, to its static load effect.

2. LITERATURE SEARCH

A literature search was carried out to ascertain whether any researchers had investigated the relationship between speed and the Impact Factor of vehicles. The results of this search are described below, under the headings of the relevant authors, and the references used are listed in Section 4, References.

Typical data from the references are shown in Figures 1 to 5. Superimposed on each diagram is the effect of a suggested increase of 10% in Impact Factor to be used for issuing Highway Permits. This effect is shown as a solid line drawn between the current specified Impact Factor, at 50 km/h, and the same value increased by 10%, at 100 km/h.

2.1 Aves (1972)

Aves (1972) considered previous theoretical and physical investigations, and also carried out tests on seven bridges, using a two axle truck with a gross weight of 8.0 t (tonnes) or 9.45 t. A typical result, from tests on a 14.6 m span, with the vehicle travelling between 8 and 80 km/h, is shown in Figure 1.

Aves proposed an impact formula based on a dimensionless speed parameter, A, itself based on vehicle speed, span length and natural period of the span, as follows:

$$A = \frac{T_b V}{2L}$$

where T_b = Span natural period
V = Vehicle speed
L = Span length

The Impact Factor, I, proposed was:

$$I = 1.25 + \frac{0.82\,A}{1-A}$$

On this basis, taking as an example the 14.6 m span with a natural period of 0.105 s, the Impact Factor would increase from 1.29 at 50 km/h to 1.34 at 100 km/h, or a 4% increase.

This appears to be a clear-cut result, but it should be noted that the vehicle used was very light compared with overweight loads, so the results are not necessarily definitive.

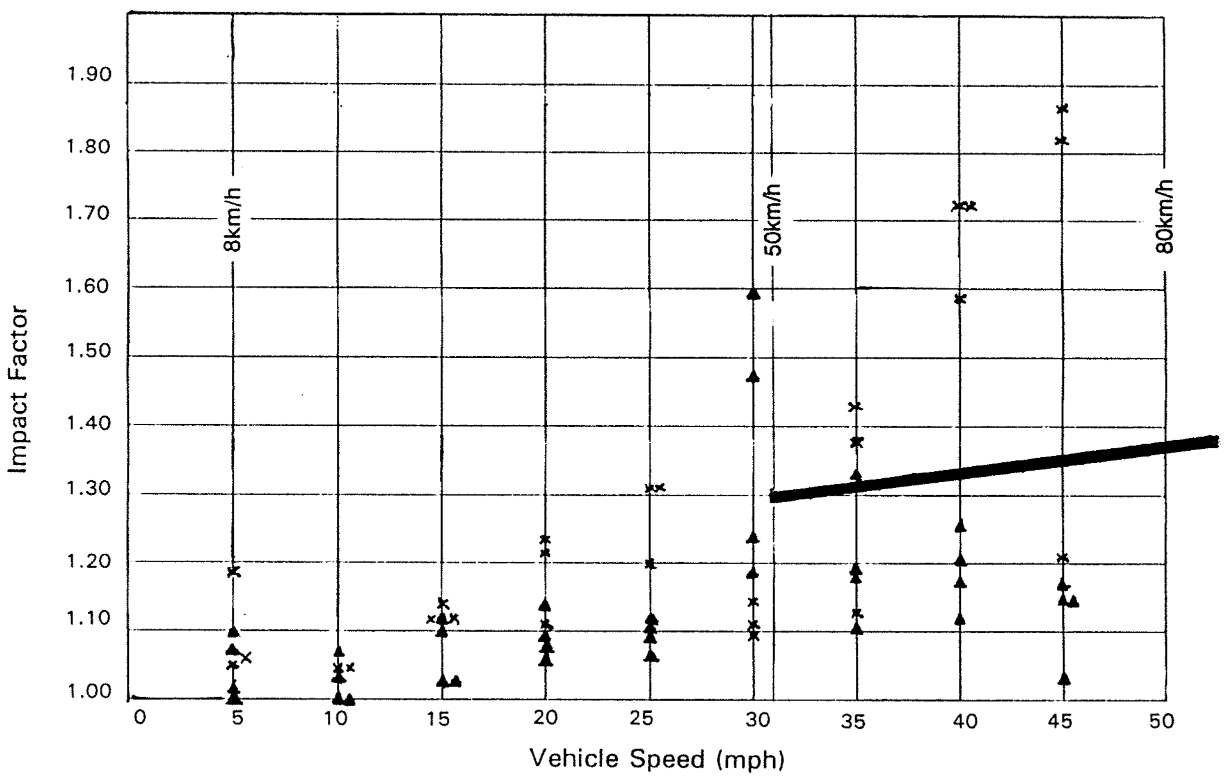
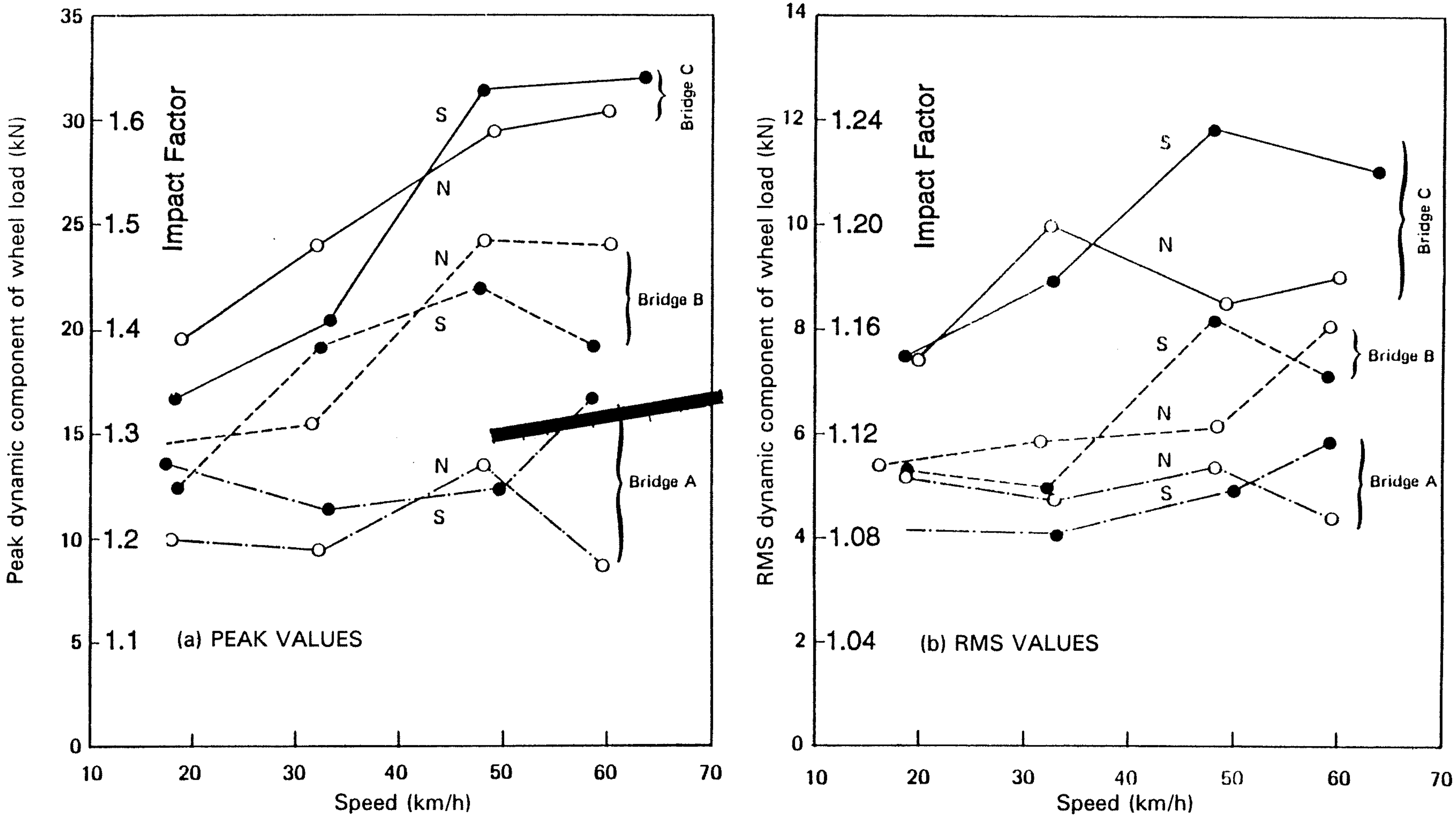


Figure 1. From Aves (1972). Impact Factors measured on a 14.6 m span. Impact Factor with suggested HPERMIT modification is superimposed.

x Unladen runs
▲ Laden runs
▬ Impact Factor with suggested HPERMIT modification



Impact Factor with suggested HPERMIT modification
(Note to (b): Impact Factor with suggested HPERMIT modification is off the diagram)
RMS Root mean square N, S Direction of travel (north, or south)

Figure 2. From Page (1976). Impact Factors measured on a 5 t wheel.
Impact Factor with suggested HPERMIT modification is superimposed.

2.2 Page (1976)

In this project, a 16 t truck was used to measure Impact Factors for a 5 t wheel, using instrumentation on the truck itself. The results are, therefore, of more relevance to deck loading than to gross loading. Page (1976) found that impact increased between 18 and 48 km/h, but that little change occurred between 48 and 60 km/h. Typical results are shown in Figure 2.

2.3 Rambhai (1980)

This project was a theoretical study using computer simulation to determine which parameters significantly affect the Impact Factor. The three vehicles simulated were 19.9 t, 36.3 t and 54.5 t gross weight respectively, and spans ranged from 9 m to 60 m.

The conclusion was that the variation of Impact Factor with speed is irregular, and that it is therefore not a significant parameter. The point is made that in some cases both maximum and minimum values occur over the same speed range. Figures 3a and 3b show typical results.

2.4 Thurston (1983)

In this project, Impact Factors were measured on two bridges for both a test vehicle and random traffic. The conclusion reached was that there was little correlation with either vehicle load or speed, with a small tendency for Impact Factor to decrease with load and to increase with speed.

To illustrate this, Figure 4 shows plots of Impact Factor against speed for the heavier vehicles of the random traffic, as recorded by strain gauges at midspan of three beams of a 20 m span. The design value of Impact Factor for this span is 1.26.

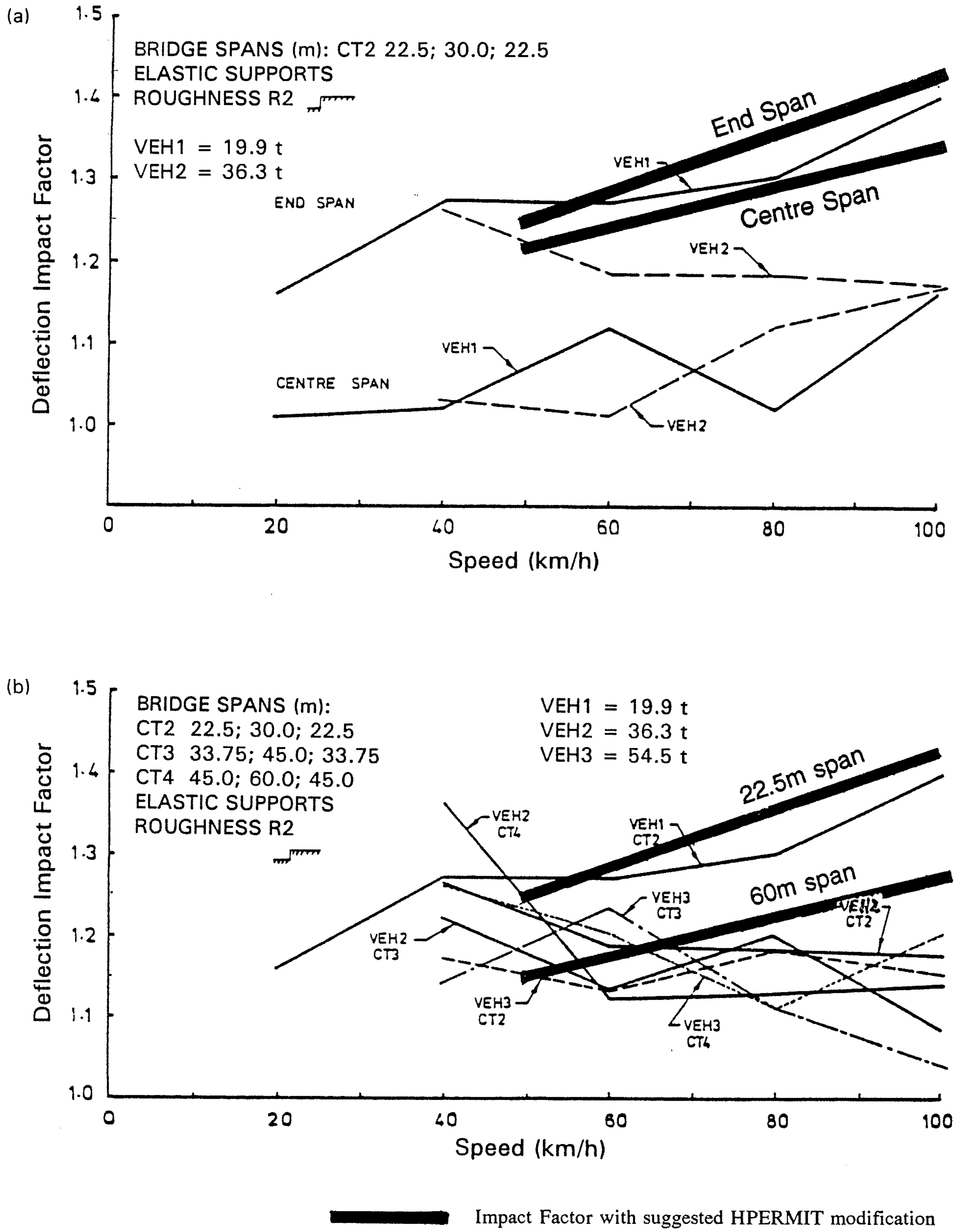


Figure 3. From Rambhai (1980). Impact Factors calculated on continuous spans. Impact Factor with suggested HPERMIT modification is superimposed.

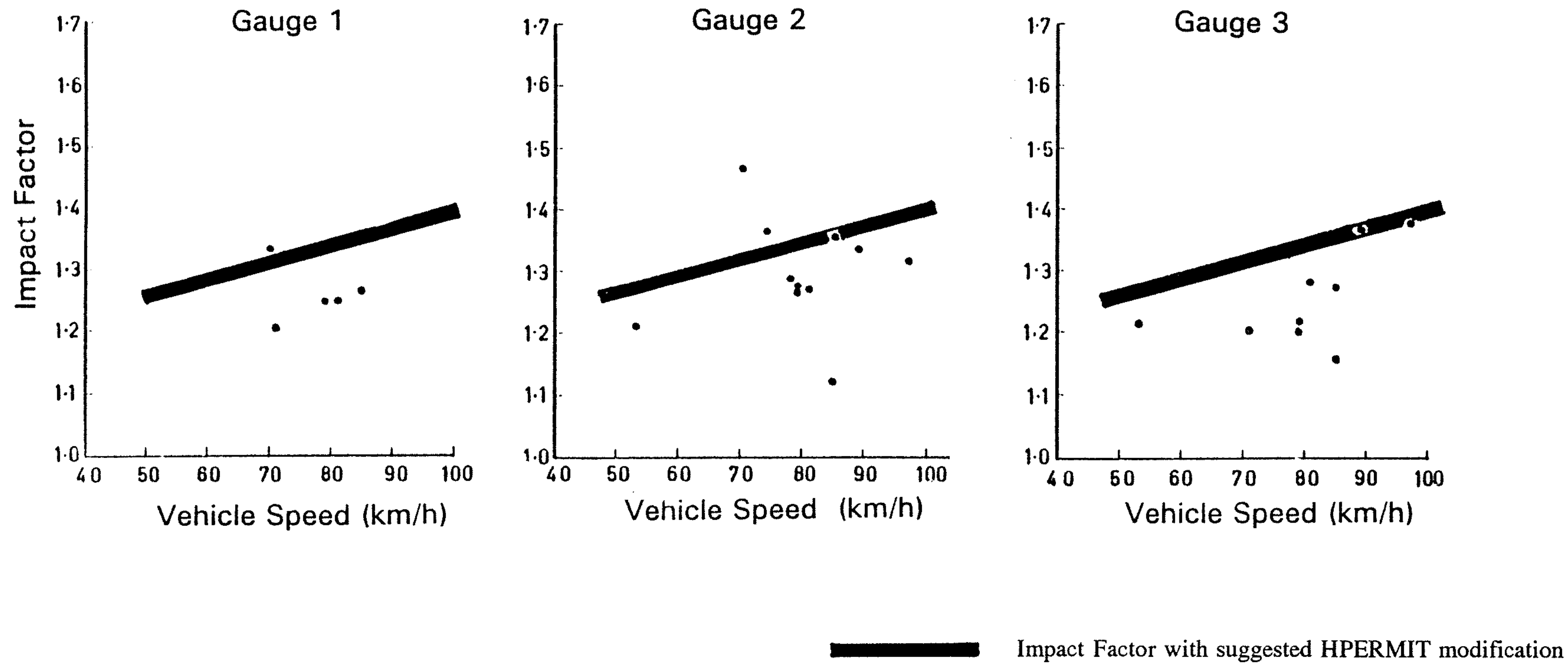


Figure 4. From Thurston (1983). Impact Factors measured on a 20 m span. Impact Factor with suggested HPERMIT modification is superimposed.

2.5 Billing and Green (1984)

This paper describes testing undertaken by Ontario Ministry of Transportation and Communications, to develop impact criteria for their bridge design code. The rules developed for the code do not refer to speed but, in the course of measurements, speed was recorded. Measurements were made of the effects of random traffic on 52 bridges.

Figure 5 shows the results from three typical bridges, plotted as amplitude factor against speed. Amplitude factor is the ratio of the dynamic portion of the deflection of the span to the equivalent load. It is hence proportional to *(I - 1)* in New Zealand terminology, where *I* is Impact Factor. The Impact Factor scale has been superimposed on the diagram.

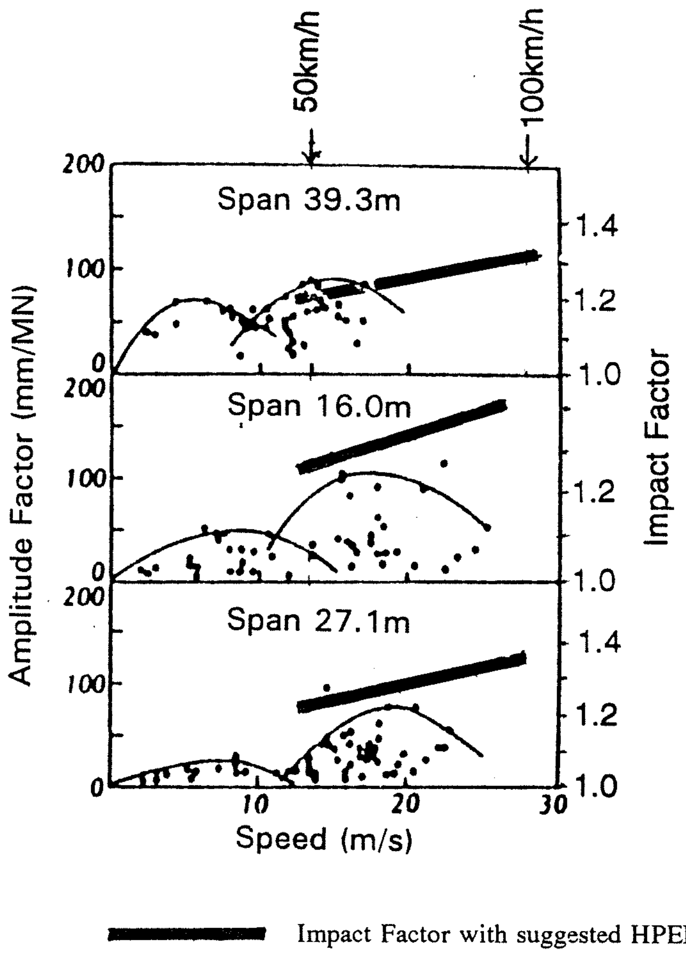


Figure 5. From Billing and Green (1984). Amplitude factors and Impact Factors measured on typical spans. Impact Factor with suggested HPERMIT modification is superimposed.

2.6 Melcer (1988)

This paper (in Polish, with English abstract) gives theoretical results for three idealised vehicles on three spans, and compares them with experimental results for two of these. The theoretical results, which are for speeds up to 120 km/h, support the conclusion in this report that Impact Factor of overweight vehicles at 100 km/h should be considered to be 10% greater than at 50 km/h. However the experimental results cover only speeds up to 47 km/h and appear to be inconclusive.

2.7 Haifan (1989)

Haifan (1989, in Chinese, with English abstract) gives theoretical results for an idealised vehicle on three spans with different natural frequencies. Impact is triggered by a ramp at the start of the span, and by an artificial bump part way along the span. For one span, the theoretical results are compared with experimental results, but the speed range is only up to 50 km/h and so is not of direct relevance to this report.

2.8 Other Work

In spite of the number of references available, very few address the variation of Impact Factor with speed. One other reference, Sanpaolesi et al. (1984, in Italian), was noted as being relevant but could not be obtained.

3. CONCLUSIONS

3.1 General

The literature search described in Section 2 was carried out to determine if a recognised relationship exists between speed and Impact Factor.

In all the references studied, the conclusion has been that the relationship is not easily quantifiable. However, there is a discernible trend, and it is considered reasonable to allow for the trend by assuming a 10% increase in the Impact Factor currently used, to compensate for a speed increase from 50 to 100 km/h.

In Figure 2, which shows results applicable to deck slab loading, the Impact Factor is exceeded by a wide margin on the basis of peak values, even when increased by the proposed 10% at 100 km/h. However, on the basis of RMS (root mean square) values, the current Impact Factor would be sufficient.

As can be seen from the figures reproduced, a percentage of vehicles are likely to exceed the current Impact Factor even at the 50 km/h limit. The general question of whether the current values are appropriate is outside the scope of this report, but is currently being addressed in Transit New Zealand, Research & Development (R&D) Project PR3-0074, "Bridge Impact Factor".

3.2 Highway Permits

Modifications to the Highway Permits program (operated by Transit New Zealand) to implement the suggested 10% increase could be made in either of two ways, (a) or (b), as described below:

(a) Apply the suggested 10% increase to the Impact Factor for Restriction Level 0, and allow the speed of all overweight vehicles at that Level to be the legal maximum.

(b) Introduce a new Restriction Level (say A) before Restriction Level 0, to which the criteria described in (a) would apply, and maintain the remaining Restriction Levels 0 to 4 as they are. The table of Restriction Levels would then be:

Table of Restriction Levels

Restriction Level	Requirements
A	Normal heavy motor vehicle requirements
0	Speed restricted to 50 km/h in own lane
1	Speed restricted to 20 km/h in own lane
2	Speed restricted to crawl in own lane
3	Crawl speed, no other traffic on the bridge and truck central on bridge
4	Truck must not cross

Transporters and cranes would have the option of Restriction Level A. All other vehicles would start at Restriction Level 0.

In the TRUCK command, provision would be made for a label to be input by the user to identify "transporters and cranes."

3.3 Further Work

Measurements of Impact Factor are to be made on a selection of bridges under Transit New Zealand R&D Project No. PR3-0074, "Bridge Impact Factor". If vehicle speed is recorded at the same time, this will enable the conclusions reached in this report to be verified or amended according to the results.

4. REFERENCES

Aves, R J. 1972. *An investigation of highway bridge impact loading*. Thesis for Master of Engineering, University of Canterbury. 74 pp.

Billing, J.R., Green, R. 1984. Design provisions for dynamic loading of highway bridges. *Transportation Research Record No.* 950: 94-103. Transportation Research Board, Washington, DC.

Haifan, X. 1989. Research on simply supported beam bridge vibration due to vehicular loads. *Journal of Tongji University* 17(4): 456-465.

Melcer, J. 1988. Dependence of dynamic factor of the bridge on the speed of vehicle motion. *Stavebnícky Časopis* 36(1): 3-18.

Page, J. 1976. Dynamic wheel load measurements on motorway bridges. *TRRL Report* 722. Transport and Road Research Laboratory, Crowthorne, Berkshire.

Rambhai, P. 1980. Parameter study for bridge impact factors. *RRU Research Project* 4789. Structures Committee, National Roads Board, Road Research Unit, Wellington.

Sanpaolesi, L., Caramelli, S., Del Corso, R., Favilli, A. 1984. Measurements and interpretation of dynamic loads on bridges (2nd phase). *Report No. EUR-8928 Commission of the European Communities,* Luxembourg. 280 pp.

Thurston, S.J. 1983. Impact factors measured on two bridges. *Central Laboratories Report No.* 5-83/4. 116 pp. Ministry of Works and Development, Lower Hutt.