Critical Loading Events For The Assessment Of Medium Span Bridges

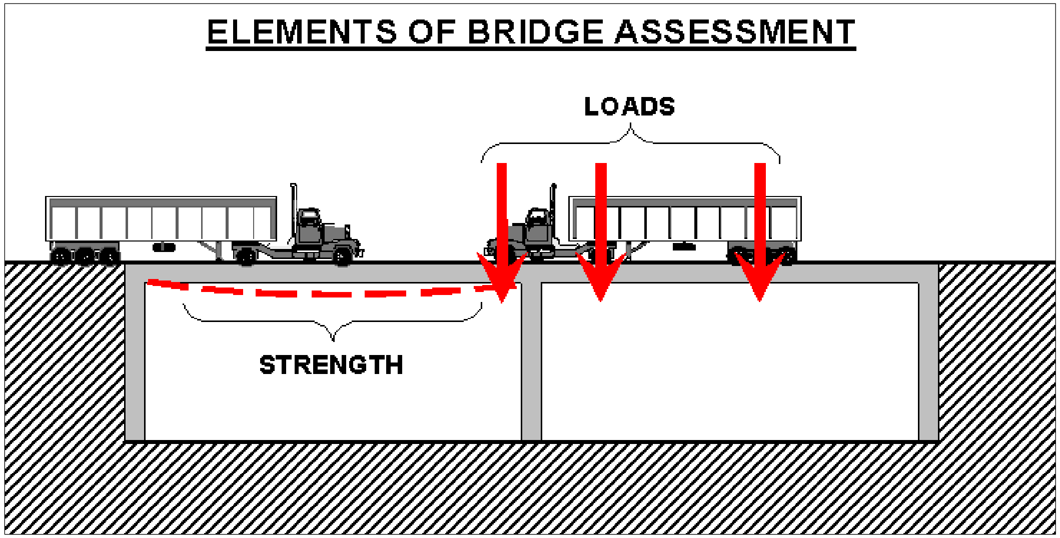
C.C. Caprani, S.A. Grave, E.J. O'Brien, A.J. O'Connor

Bridge assessment is critical in maintaining our bridge stock

Proper assessment can save €m's

With future EU legislation for heavier trucks probable, this is more important than ever

Strength is relatively easy to assess given today's material technologies



This paper examines the loads in a bridge assessment:

- We describe numerical modelling of truck flows & truck loading events
- We look at medium spans (20 – 50 m) and determine the critical loading states
- We explain the statistics used to determine the characteristic values of the load effects

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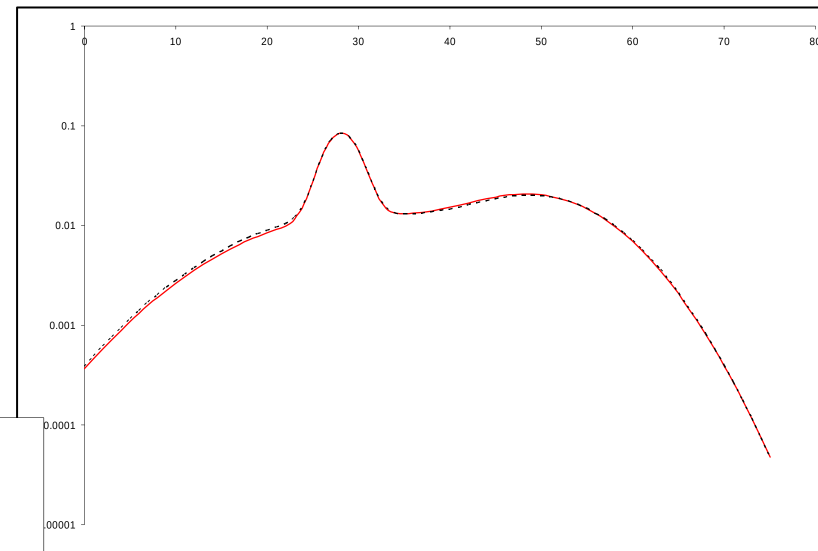
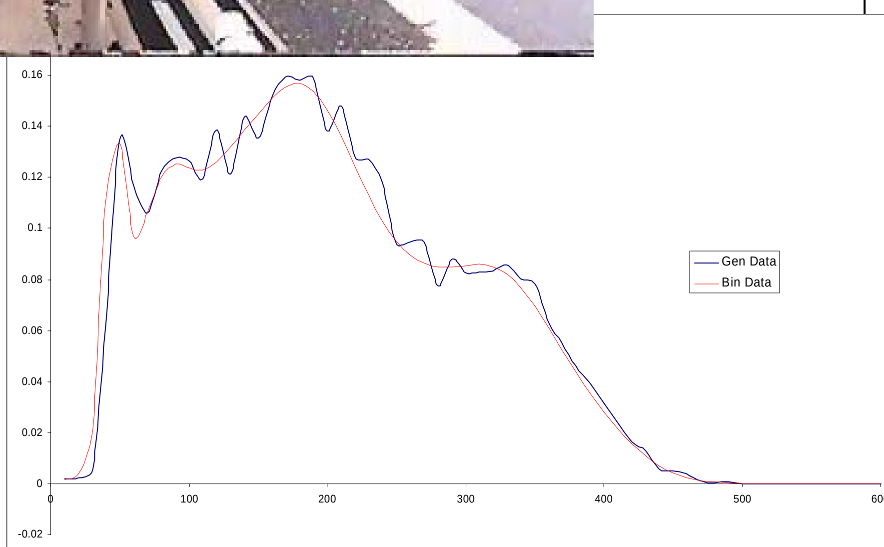
Generating Traffic

1. Real traffic is measured using Weigh-In-Motion at a site in France, near Angers.

2. Statistical distributions are fitted to this data to model all the parameters of the truck flow.





3. Random trucks are generated that fit these distributions.

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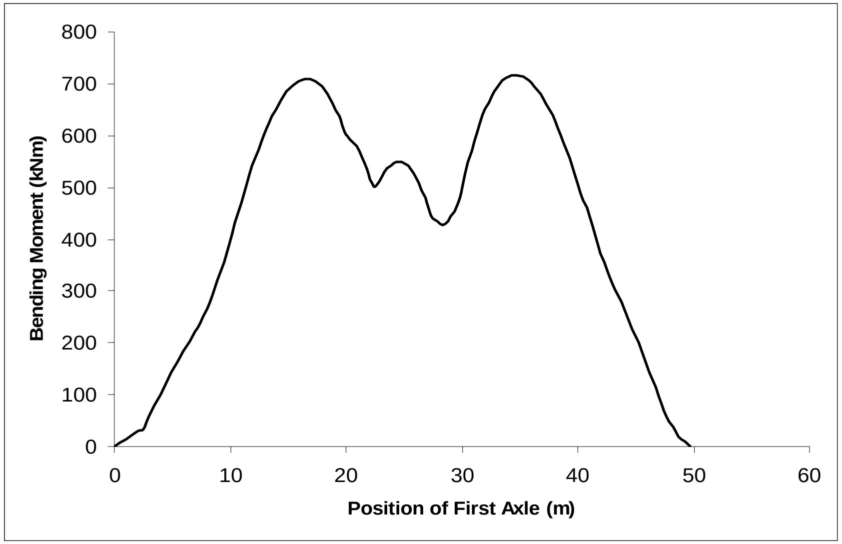
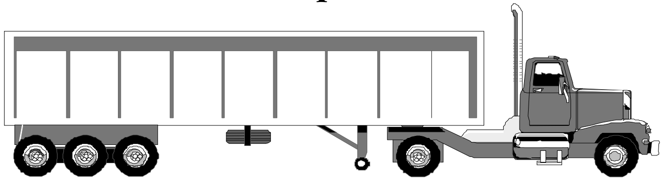
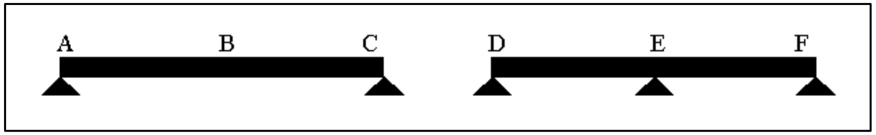
Static Effects

Using influence lines, static bridge responses are calculated.

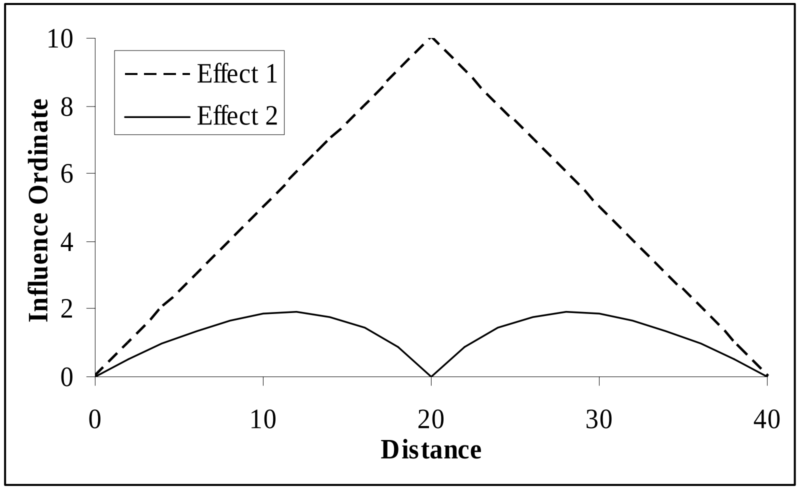


This diagram is the hogging bending moment history over the middle support in a 40 m continuous span for a 5-axle truck:





In this paper we examine the load effects at locations B and E (Effect 1 & 2 respectively) given by the influence lines below:



Influence lines for a 40 m bridge length

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Event Definitions

To minimise processing we only perform load effect calculations if:

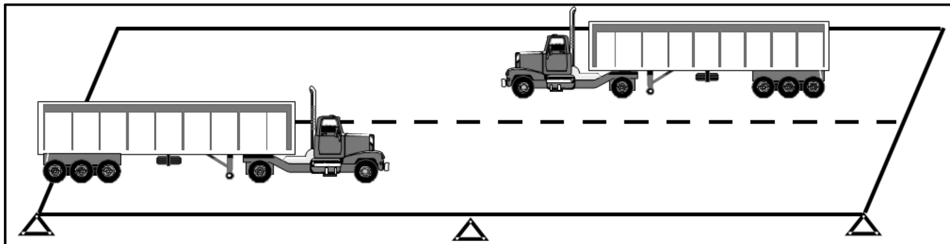
1. Multiple truck presence event (MTPE);
2. Single truck with GVW ≥ 50 tonnes.

Define:

EV1 – single truck event

EV2 – two truck event

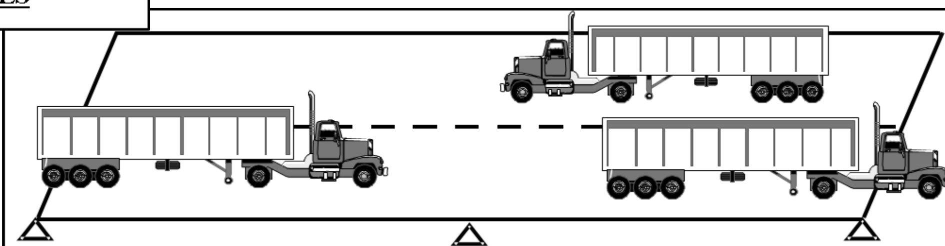
EV3 – three truck event



TWO TRUCK EVENTS IN MEDIUM SPAN BRIDGES

Currently, only single & two truck events (EV12) tend to be modelled…

But in medium spans 3-truck events could make a difference…



POSSIBLE EVENTS IN MEDIUM SPAN BRIDGES

To establish if 3-truck events should be modelled we examine the difference in results of:

EV12 – one & two-truck flows

EV123 – one, two & three truck events

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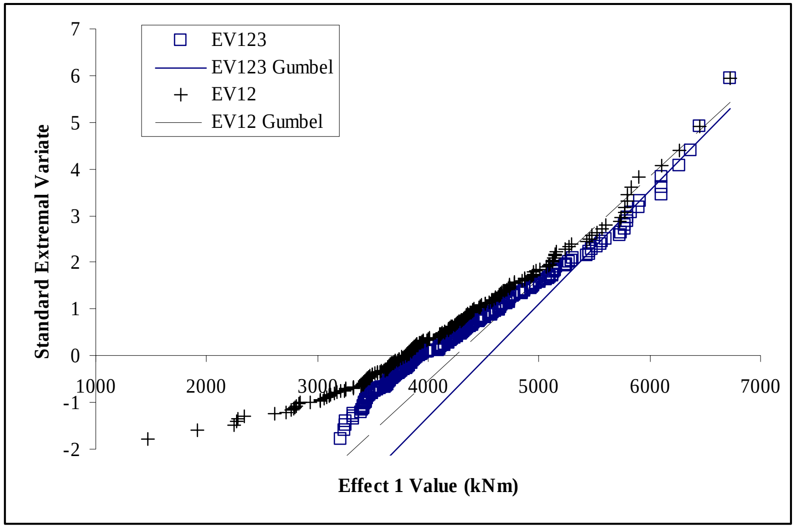
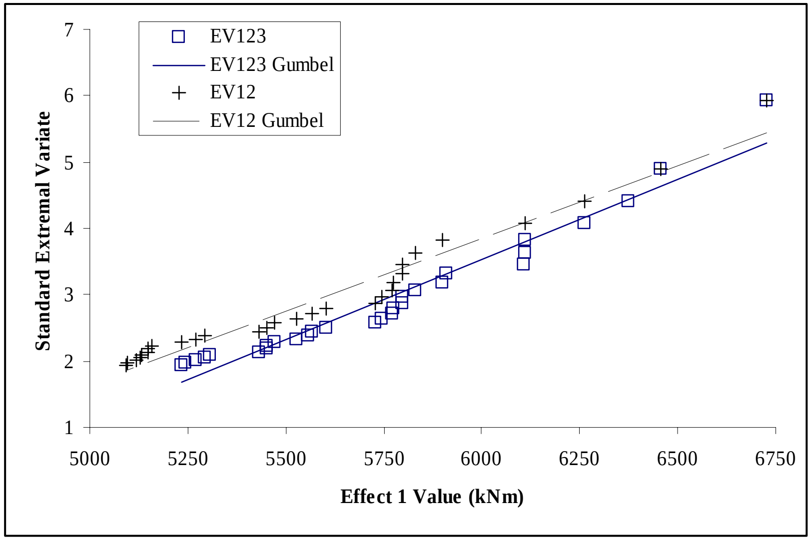
Prediction of Extreme Load Effects

Extreme value statistics is used to exptrapolate from the 10 day simulation to the 1000 year values of the load effects…

240 hourly maximums were used as the Gumbel type distribution population…



Lines are fitted to the data on probability paper: y = mx + c characterises the distribution



15.6 on the y-axis corresponds with a 1000-year return period; thus, knowing the line equation we establish the x-axis value.

Only $k = 2\sqrt{n}$ tail data is used in the fit…

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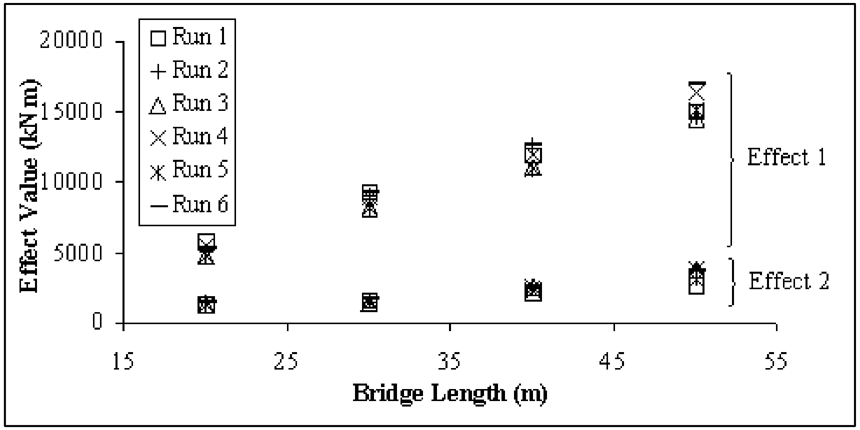
Results

To assess repeatability, 6 runs were produced:



Results for EV123: It can be seen that the results are quite consistent.

The mean results of the 6 runs are given in the table for EV12 & EV123.

The EC1.3 design value is also given…

Length	Effect	Event	Mean	EC 1.3	Difference (%)
20 m	1	EV12	5305	6913	30
		EV123	5216	6913	33
	2	EV12	1358	1440	6
		EV123	1339	1440	8
30 m	1	EV12	9006	11803	31
		EV123	8817	11803	34
	2	EV12	1546	2519	63
		EV123	1541	2519	64
40 m	1	EV12	12271	17650	44
		EV123	11836	17650	49
	2	EV12	2129	3837	80
		EV123	2412	3837	59
50 m	1	EV12	15542	24443	57
		EV123	15407	24443	59
	2	EV12	2742	5394	97
		EV123	3389	5394	59

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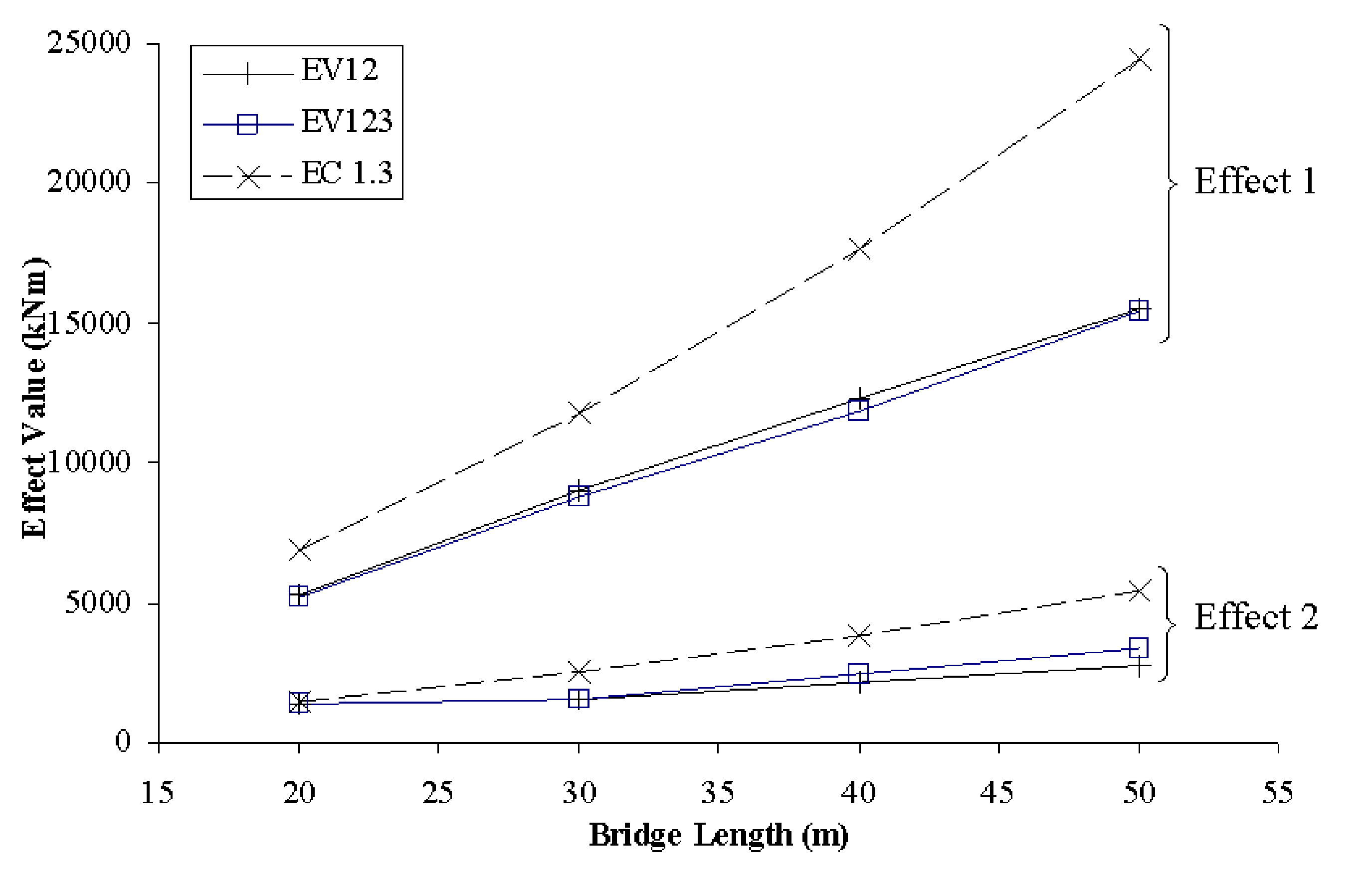
Graph of Results



Effect 1:

EV123 is 3.7% less than EV12 at 40 m

Effect 2:

EV123 is 19.1% greater than EV12 at 50 m

EC1.3:

The large difference shows the value of site-specific assessment

As the two effects display different behaviour, and all other things being equal, the difference in behaviour can only be attributed to the influence line

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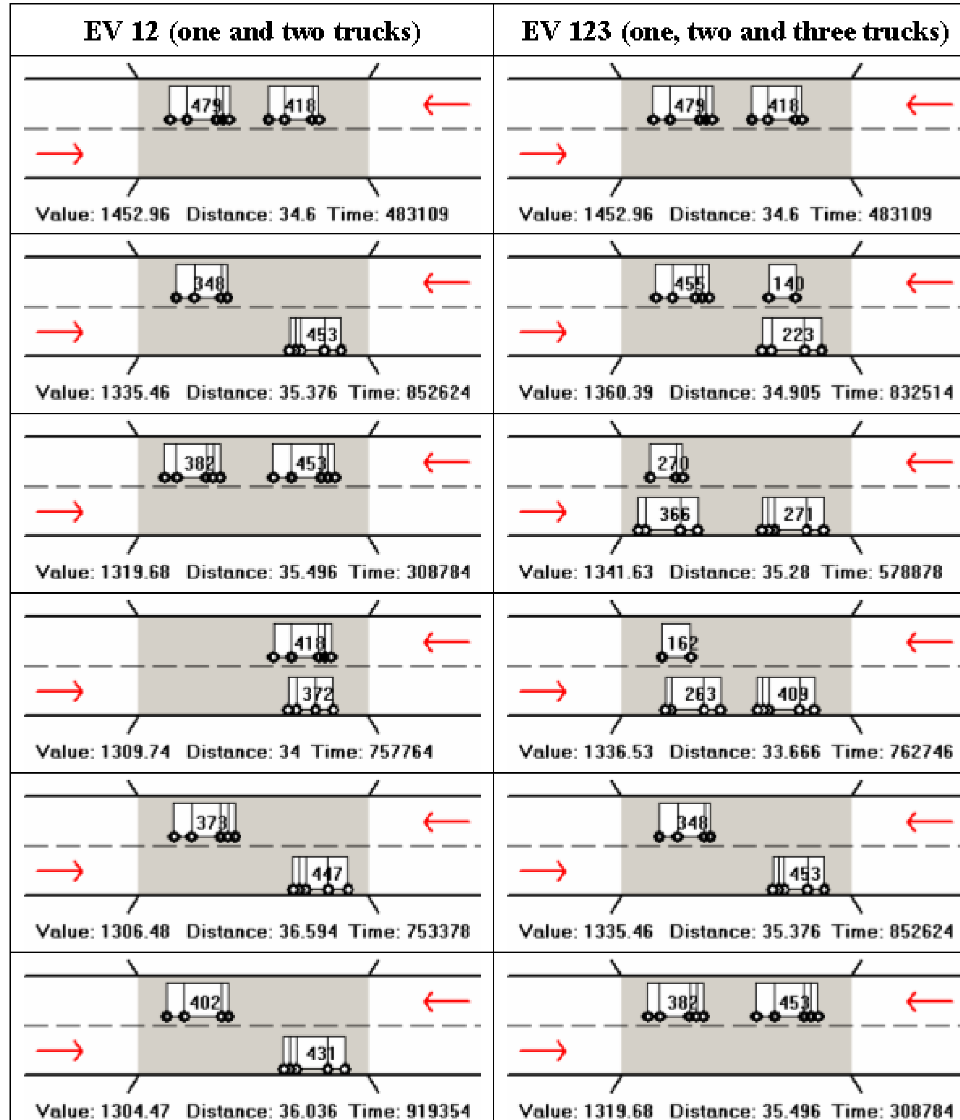
Basis of Results

The top six events for Run 1, Effect 2:

The influence of the third truck is apparent as the 2nd most critical EV12 is the 5th most critical EV123…

Thus it is appreciated that the inclusion of three truck events can affect the extrapolated value, as found.



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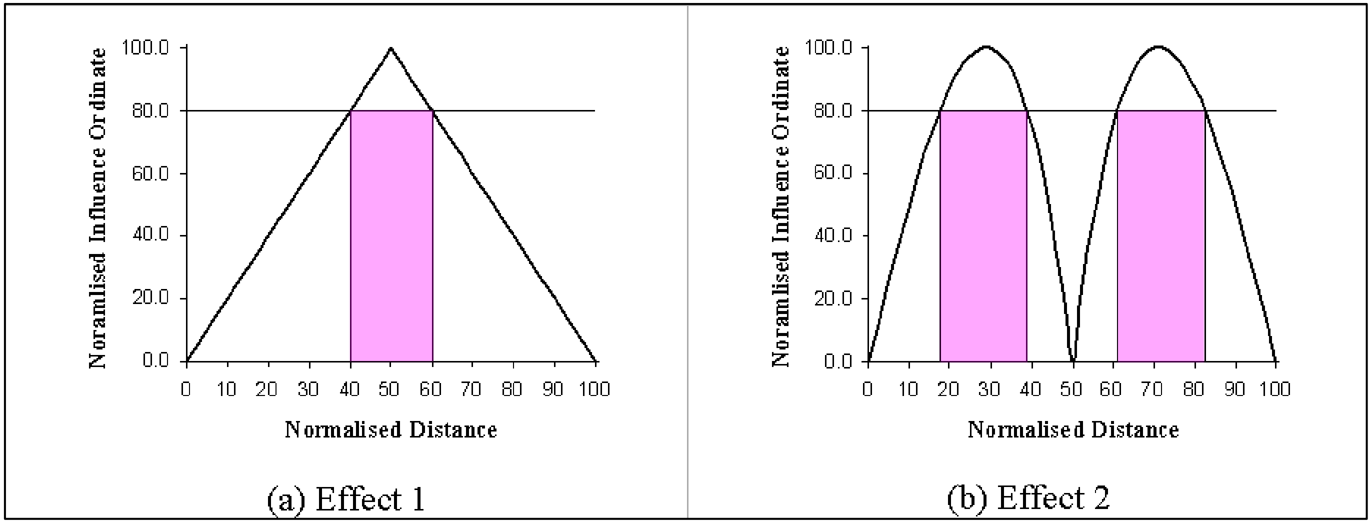
Explanation of Results

The three truck event affects the deisgn values; how much depends on the influence line:

The following shows areas of 80+% ordinates & corresponding length:



Effect 1: 20% of length **Effect 2: 44% of length**

Note that for Effect 1 we predict EV123 < Ev12; an unusual result…

This is due to the lines of the Gumbel graphs crossing before 15.6 and was not expected!

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Conclusions

1. The two truck event is the most important for medium span bridges.
2. Three truck events may be critical for less peaked influence lines in the longer spans.
3. Including three truck events may decrease the characteristic effect value.
4. Single trucks did not feature in any of the most critical events.

In assessing site-specific bridge loading for bridge lengths up to 50 m and in free flowing situations, both two and three truck events should be modelled.

Acknowledgments

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