Forth Estuary Transport Authority
Forth Road Bridge

2010 Bridge Specific Assessment Live Loading

Return Periods Addendum Report

February 2011

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CONTROL SHEET FAIRHURST

CLIENT: **Forth Estuary Transport Authority**

PROJECT TITLE: **Forth Road Bridge 2010 BSALL**

REPORT TITLE: **2010 Bridge Specific Assessment Live Loading Return Periods Addendum Report**

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This report has been prepared in accordance with procedure OP/P03 of W A Fairhurst & Partners' Quality Assurance System.

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1 INTRODUCTION

The Forth Road Bridge currently adopt a Bridge Specific Assessment Live Loading (BSALL) for the assessment of the suspended structure to carry day to day loading which may occur on the bridge. The BSALL is derived from traffic data recorded at the bridge with the calculated loading having a 5% probability of occurrence in 120 years. However in order to prioritise remedial and upgrading works FETA commissioned W.A. Fairhurst & Partners to derive BSALL loading curves with shorter return periods.

This report provides BSALL loading curves for return periods of 10, 50 and 120 year periods. The 120 year period loading is the recommended BSALL for the bridge and is provided for comparison. Full details of the recommended BSALL including the principles of which have been used to derive the BSALL, are provided in our report “2010 Bridge Specific Assessment Live Loading” dated February 2011.

2 CALCULATION FOR SHORTER RETURN PERIODS

The calculation of the BSALL for reduced return periods has been undertaken in a similar manner to that to derive the recommended 2010 BSALL.

The effect of reducing the return period is taken into account in the calculation of the tail probability. This is then used to determine the number of standard deviations from the mean for a variable of a specific probability of occurrence. As the calculated probability reduces with reducing the return period the number of standard deviations from the mean (r) for the variable also reduces. This effect is shown in the tables in Appendix B with r reducing from approximately 5.5 to 5.0 between 120 years and 10 years respectively

3 COMPARISON OF CALCULATED BSALL FOR REDUCED RETURN PERIODS

A BSALL has been derived for reduced return periods of 50 years and 10 years. The total bridge loading and lane 1 loadings for these return periods are plotted in Figures 1 and 2 respectively of Appendix A along with the 2010 recommended loading for comparison. The bridge total loading has been calculated using the same lane factors adopted for the recommended loading. The lane factors are 1.0, 0.67, 0.33 and 0.33 for lanes 1 to 4 respectively.

The reduction in return period results in the following reduction in the calculated critical lane 1 loading;

- For a 50 year return period the loading reduces by an average of 3%.
- For a 10 year return period the loading reduces by an average of 8%.

Lane factors for the nominal BSALL (120 year return period) are derived as follows.

- Lane 1 is derived on the basis of a 5% probability of occurrence in 120 years,
- Lane 2 is derived in a similar manner to Lane 1,
- Lanes 3 and 4 are based on the mean queue weights which are assumed to be co-existent with lanes 1 and 2 loading.

In considering the above we considered that retaining the lane factors from the standard BSALL derivation would remain appropriate.

4 REFERENCES

1. Research Perspectives: Traffic loading on highway bridges, Peter Dawe TRRL. Thomas Telford Publishing 2003.

2. 2010 Bridge Specific Assessment Live Loading Report by W.A. Fairhurst & Partners dated January 2011.

APPENDIX A – FIGURES

Figure 1 : BSALL for Return Periods of 120 years, 50 years and 10 years (Nominal) - Bridge Total

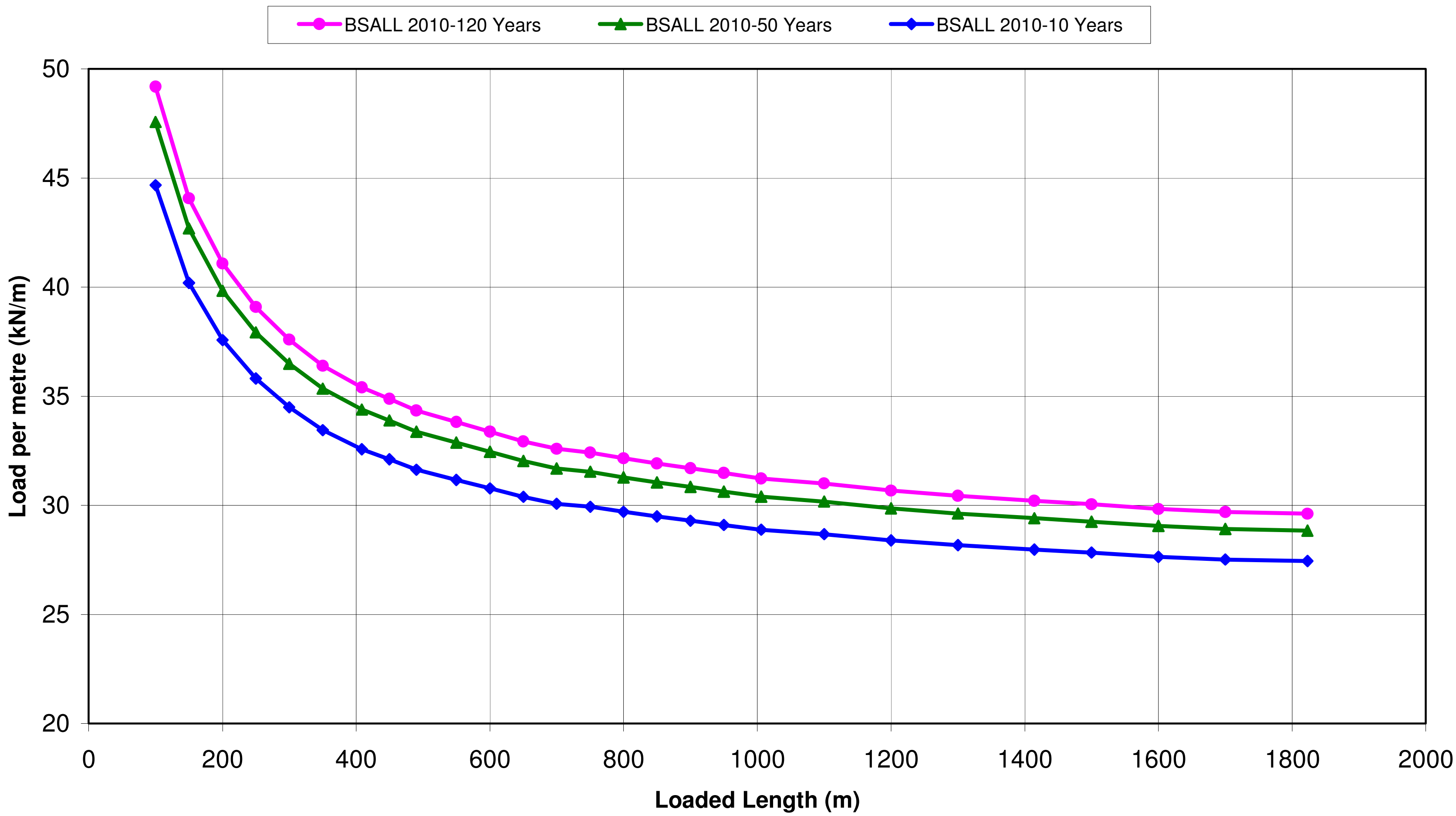
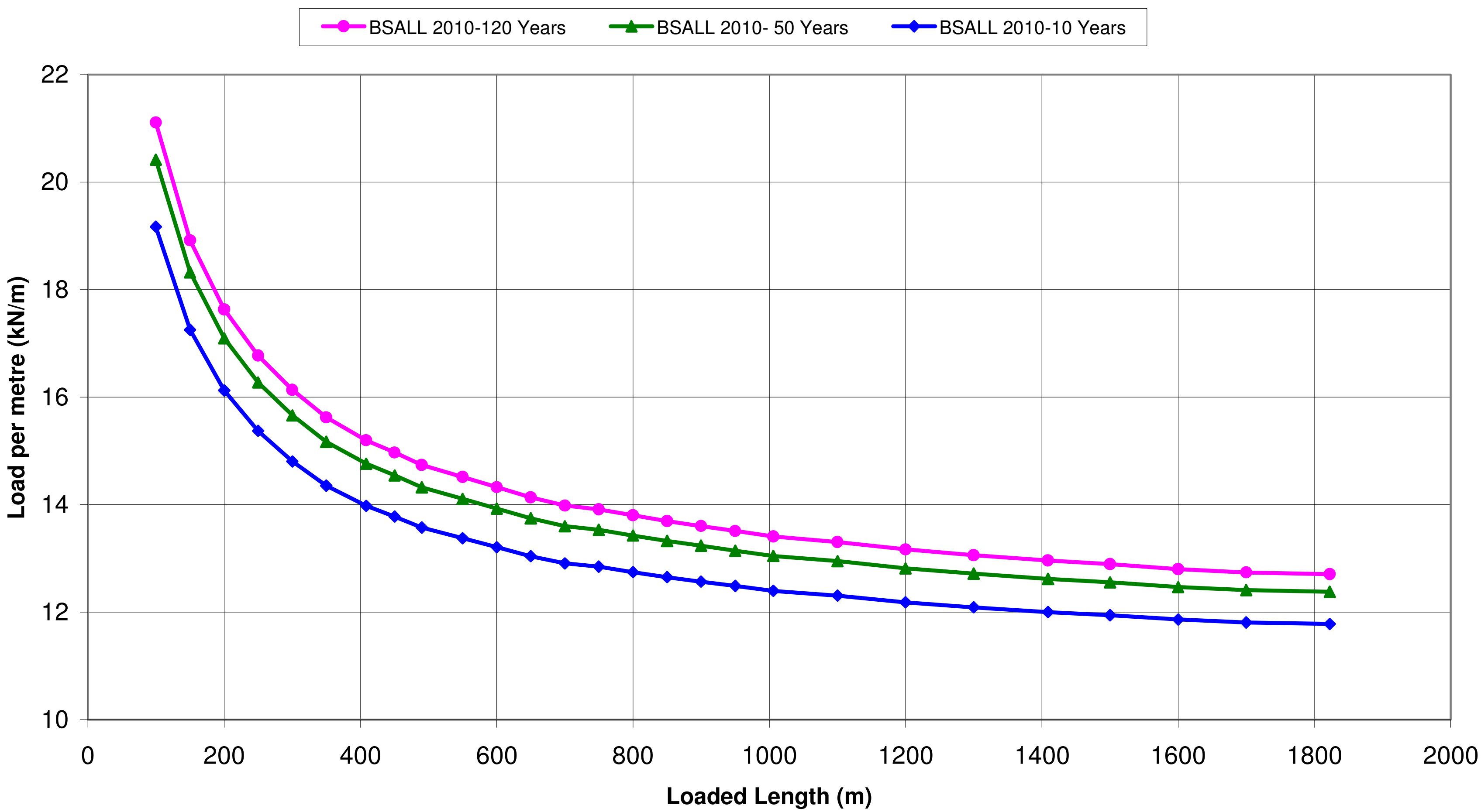


Figure 2 : BSALL for Return Periods of 120 years, 50 years and 10 years (Nominal) - Lane 1



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APPENDIX B – TABLES

Table 1 : Calculation of the 2010 assessment loading for the northbound slow lane based on a return period of 120 years.

Table 2 : Calculation of the 2010 assessment loading for the northbound slow lane based on a return period of 50 years.

Table 3 : Calculation of the 2010 assessment loading for the northbound slow lane based on a return period of 10 years.

LEGEND

P (tail probability) and 'r' :

The calculation of P (tail probability) takes account of the probability that the derived loading has a 5% chance of being exceeded in the assumed return period. The factor 'r' is the number of standard deviations from the mean corresponding to the tail probability.

Mean and 's' :

The mean of the square root of each of the individual queue weights obtained from the analysed traffic data. 's' is the standard deviation of the mean.

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Table 1 Calculation for Northbound slow lane for a return period 120 years

Loaded Length (m)	Survey No. of events	Average No. of vehicles in queue	No. of events per year	No. of events in 120 years	No. of vehicles involved in Queues (1.93%)	P Probability	r	mean	s	Characteristic Loading kN/m	Nominal Loading kN/m
100	72406	15	1258485	151018229	2914652	1.72E-08	5.518	20.31	5.53	25.33	21.11
200	72249	28	1255756	150690771	2908332	1.72E-08	5.518	20.54	4.70	21.16	17.63
300	71759	42	1247240	149668771	2888607	1.73E-08	5.517	20.60	4.32	19.36	16.13
408	71156	58	1236759	148411086	2864334	1.75E-08	5.515	20.62	4.08	18.24	15.20
1006	68634	142	1192924	143150914	2762813	1.81E-08	5.509	20.67	3.60	16.09	13.41
1414	66385	199	1153835	138460143	2672281	1.87E-08	5.503	20.73	3.47	15.55	12.96
1823	63930	256	1111164	133339714	2573456	1.94E-08	5.496	20.80	3.39	15.25	12.71

Table 2 Calculation for Northbound slow lane for a return period 50 years

Loaded Length (m)	Survey No. of events	Average No. of vehicles in queue	No. of events per year	No. of events in 50 years	No. of vehicles involved in Queues (1.93%)	P Probability	r	mean	s	Characteristic Loading kN/m	Nominal Loading kN/m
100	72406	15	1258485	62924262	1214438	4.12E-08	5.366	20.31	5.53	24.50	20.42
200	72249	28	1255756	62787821	1211805	4.13E-08	5.37	20.54	4.70	20.51	17.10
300	71759	42	1247240	62361988	1203586	4.15E-08	5.36	20.60	4.32	18.79	15.66
408	71156	58	1236759	61837952	1193472	4.19E-08	5.363	20.62	4.08	17.71	14.76
1006	68634	142	1192924	59646214	1151172	4.34E-08	5.356	20.67	3.60	15.65	13.05
1414	66385	199	1153835	57691726	1113450	4.49E-08	5.351	20.73	3.47	15.14	12.62
1823	63930	256	1111164	55558214	1072274	4.66E-08	5.344	20.80	3.39	14.85	12.38

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Table 3 Calculation for Northbound slow lane for a return period 10 years

Loaded Length (m)	Survey No. of events	Average No. of vehicles in queue	No. of events per year	No. of events in 10 years	No. of vehicles involved in Queues (1.93%)	P Probability	r	mean	s	Characteristic Loading kN/m	Nominal Loading kN/m
100	72406	15	1258485	12584852	242888	2.06E-07	5.086	20.31	5.53	23.01	19.17
200	72249	28	1255756	12557564	242361	2.06E-07	5.085	20.54	4.70	19.35	16.13
300	71759	42	1247240	12472398	240717	2.08E-07	5.084	20.60	4.32	17.77	14.81
408	71156	58	1236759	12367590	238694	2.09E-07	5.083	20.62	4.08	16.77	13.98
1006	68634	142	1192924	11929243	230234	2.17E-07	5.076	20.67	3.60	14.87	12.40
1414	66385	199	1153835	11538345	222690	2.25E-07	5.071	20.73	3.47	14.40	12.00
1823	63930	256	1111164	11111643	214455	2.33E-07	5.064	20.80	3.39	14.14	11.78

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