

FORTH ROAD BRIDGE

Strengthening of End Link Brackets For The North East and South East Towers

Approval in Principle Addendum



FAIRHURST

CONTROL SHEET

CLIENT: Amey

PROJECT TITLE: Forth Road Bridge
Strengthening of End Link Brackets

REPORT TITLE: Approval in Principle Addendum

PROJECT REFERENCE: 109178A

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Issue & Approval Schedule	Issue 1	Name		Signature		Date
	Prepared by					18/11/15
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	2				By	
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					Approved	
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					Approved	

This document has been prepared in accordance with procedure OP/P02 of the Fairhurst Quality and Environmental Management System (QEMS). This document and its contents have been prepared for and are intended solely for Amey's information and use in relation to the Strengthening of the End Link Brackets for the North East and South East towers of the Forth Road Bridge. Fairhurst accepts no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

1 INTRODUCTION

The document should be read in conjunction with the Forth Road Bridge Approval in Principle for the Strengthening of End Link Brackets for the North East and South East Towers.

The aim of the proposed strengthening works is to reduce the level of risk associated with the assessed utilisation ratios of particular parts of the link bracket arrangement and in particular the high utilisation ratios in the existing welds which were determined as part of the stiffening truss assessment. The new welds have been designed to reduce the utilisation ratios in the existing welds to less than 1.00 after strengthening and take account of the distribution of live load between existing and new weld areas. The aim of the additional top flange plate is to create a cross section of the bracket inside the tower more similar to that provided outside the tower i.e. an I section.

The proposed strengthening works will comprise of the following:

- Strengthening and partial removal of the existing stiffeners to gain an access to the inner face of the main tower plate,
- Welding of the support brackets to the inner face of the main tower plate,
- Welding of the support brackets to the back stiffeners,
- Installation of a new stiffening plate (top flange) to the support bracket,
- Filling a hole in the diaphragm plate around the existing stiffeners with steel plate.

The design criteria for the strengthening works have been carried out based on a number of proposed departures from standards. The applications for these departures have been provided in Appendix A which comprises of the following;

- Departure No. 001: Concrete Load Factor
- Departure No. 002: Superimposed Load Factors
- Departure No. 003: BSALL Lane Factors
- Departure No. 004: BSALL Load Factor
- Departure No. 005: Wind Loading

Appendix A

Applications for Departures from Standards

SUBMISSION FOR VOLUME 1, 2 AND 3 DEPARTURE FROM STANDARDS

DEPARTURE FROM STANDARDS

Name of Works:

Strengthening of End Link Brackets For N.E & S.E Towers

(Bridges and other Highway Structures)

Name of Bridge or Structure: Forth Road Bridge

Structure Reference Number: N/A

OVERSEEING ORGANISATION NAME: Transport Scotland

APPLICATION FOR DEPARTURE FROM STANDARDS – DMRB Vol 1 Section 3 Part 14 BD 37/01

APPLICANT: Fairhurst

PROJECT TITLE: Strengthening of End Link Brackets For N.E & S.E Towers

DEPARTURE No: 001

STRUCTURE REF: Forth Road Bridge

SUBMISSION DATE: 19/11/15

1. List of supporting documentation

Standards: Design Manual For Roads and Bridges (DMRB) Volume 1 Section 3 Part 14 DB 37/01

Drawings: None

Other: Loading and Structural Integrity Volume VI by W. A. Fairhurst & Partners Dated July 1986

2. Description of proposed departure

(Include details of DMRB / Eurocode Standards and Clause numbers which are being departed from)

Departure from Table 1 load factors. Reduced concrete load factor of 1.08 for ULS combinations

3. Designer / Assessor justification

(Include reasons why existing DMRB / Eurocode Standards are inappropriate)

A reduced load factor γ_{fl} of 1.08 for the dead load of the concrete deck will be adopted. The reduced load factor is based on the results of tests undertaken on samples of the concrete deck to determine the thickness and density of the concrete. Details of the testing are given in, Report on Loading and Structural Integrity Volume VI by W. A. Fairhurst & Partners Dated July 1986. This is the same load factor adopted by previous bridge management and reflects the uniqueness of the Forth Road Bridge and is consistent with the concept of a Bridge Specific Live Loading.

4. Cost implications

(Include an estimate of cost savings to Transport Scotland as well as the effect on future maintenance costs)

4.1. Construction costs

Adopting standard loading and load factors for the assessment of the bridge and design of strengthening works will lead to significant works across the bridge structure to achieve code compliance. Reducing the load factor for the bridge reduces the extent of interventions required. The approach proposed by this departure is considered a pragmatic response to the assessed structural issues

4.2. Maintenance costs

N/A

5. Applicant design of the Works Team Leader Declaration:

I declare that reasonable professional skill and care have been exercised in the preparation of this Departure submission.

Signed:

Name: C. A. Cunn

Date: 19th Nov 2015

6. Overseeing Organisation Bridges Branch Comments and Recommendation:

I recommend that the above departure should be accepted / rejected

Signed:

Name:

Date:

7. Overseeing Organisation Recommendation

The above Departure is approved / rejected.

Signed:

Name:

Date:

SUBMISSION FOR VOLUME 1, 2 AND 3 DEPARTURE FROM STANDARDS

DEPARTURE FROM STANDARDS

Name of Works:

Strengthening of End Link Brackets For N.E & S.E Towers

(Bridges and other Highway Structures)

Name of Bridge or Structure: Forth Road Bridge

Structure Reference Number: N/A

OVERSEEING ORGANISATION NAME: Transport Scotland

APPLICATION FOR DEPARTURE FROM STANDARDS – DMRB Vol 1 Section 3 Part 14 BD 37/01

APPLICANT: Fairhurst

PROJECT TITLE: Strengthening of End Link Brackets For N.E & S.E Towers

DEPARTURE No: 002

STRUCTURE REF: Forth Road Bridge

SUBMISSION DATE: 19/11/15

1. List of supporting documentation

Standards: Design Manual For Roads and Bridges (DMRB) Volume 1 Section 3 Part 14 DB 37/01

Drawings: None

Other: None

2. Description of proposed departure

(Include details of DMRB / Eurocode Standards and Clause numbers which are being departed from)

A reduced load factor of 1 and 1.2 for SLS and ULS respectively will be used in the model for the superimposed dead load carriageway surfacing in accordance with Clause 5.2.2.1 of BD 37/01.

3. Designer / Assessor justification

(Include reasons why existing DMRB / Eurocode Standards are inappropriate)

The total weight of asphalt surfacing on the bridge is controlled by Amey through management of resurfacing operations on the bridge. Where resurfacing is undertaken, overlays are not permitted and the existing surfacing is removed before a replacement surface is laid with measurement controls placed on the thickness. We have also undertaken a detailed assessment of the thickness of surfacing across the bridge spans through site measurements during resurfacing operations. The actual weight adopted in the assessment is based on the mean thickness of surfacing recorded on site. On this basis the load factor applied to the weight of the surfacing can be reduced in accordance with the Assessment Standards.

4. Cost implications

(Include an estimate of cost savings to Transport Scotland as well as the effect on future maintenance costs)

4.1. Construction costs

Adopting standard loading and load factors for the assessment of the bridge and design of strengthening works will lead to significant works across the bridge structure to achieve code compliance. Reducing the load factor for the bridge reduces the extent of interventions required. The approach proposed by this departure is considered a pragmatic response to the assessed structural issues

4.2. Maintenance costs

NA

5. Applicant design of the Works Team Leader Declaration:

I declare that reasonable professional skill and care have been exercised in the preparation of this Departure submission.

Signed:

Name: C. A. CLARK

Date: 19TH NOV 2015

6. Overseeing Organisation Bridges Branch Comments and Recommendation:

I recommend that the above departure should be accepted / rejected

Signed:

Name:

Date:

7. Overseeing Organisation Recommendation

The above Departure is approved / rejected.

Signed:

Name:

Date:

SUBMISSION FOR VOLUME 1, 2 AND 3 DEPARTURE FROM STANDARDS

DEPARTURE FROM STANDARDS

Name of Works:

Strengthening of End Link Brackets For N.E & S.E Towers

(Bridges and other Highway Structures)

Name of Bridge or Structure: Forth Road Bridge

Structure Reference Number: N/A

OVERSEEING ORGANISATION NAME: Transport Scotland

APPLICATION FOR DEPARTURE FROM STANDARDS – DMRB Vol 1 Section 3 Part 14 BD 37/01

APPLICANT: Fairhurst

PROJECT TITLE: Strengthening of End Link Brackets For N.E & S.E Towers

DEPARTURE No: 003

STRUCTURE REF: Forth Road Bridge

SUBMISSION DATE: 19/11/15

1. List of supporting documentation

Standards: Design Manual For Roads and Bridges (DMRB) Volume 1 Section 3 Part 14 DB 37/01

Drawings: None

Other: Fairhurst. '2010 Bridge Specific Assessment Live Loading + Addendum reports'. (2011)

2. Description of proposed departure

(Include details of DMRB / Eurocode Standards and Clause numbers which are being departed from)

Reduced lane factors from BD37/01 Table 14. Adopted lane factors of 1, 0.46, 0.14, and 0.14 for lanes 1, 2, 3, and 4 respectively

3. Designer / Assessor justification

(Include reasons why existing DMRB / Eurocode Standards are inappropriate)

Assessment of the main tower link arrangement have previously shown that elements of the links are overstressed under the application of recommended 2010 BSALL loading as set out in Fairhurst's 2010 Bridge Specific Assessment Live Loading + Addendum reports. In order to prioritise essential maintenance and upgrading works FETA requested that Fairhurst review the assessment of the link arrangements for a lower level of 2010 BSALL. The review determined the lowest levels of stress indices associated with a 2010 BSALL which can be safely accepted thereby limiting the extent of any upgrading required to the brackets in the short term. It was accepted that amended lane factors based on WIM calculations of 1, 0.46, 0.14, and 0.14 can be adopted for lanes 1, 2, 3, and 4 respectively

4. Cost implications

(Include an estimate of cost savings to Transport Scotland as well as the effect on future maintenance costs)

4.1. Construction costs

Adopting Lane factors as set out in Fairhurst's 2010 BSALL report for the assessment of the bridge and design of strengthening works will lead to significant works across the bridge structure to achieve code compliance. Reducing the load factor for the bridge reduces the extent of interventions required. The approach proposed by this departure is considered a pragmatic response to the assessed structural issues

4.2. Maintenance costs

NA

5. Applicant design of the Works Team Leader Declaration:

I declare that reasonable professional skill and care have been exercised in the preparation of this Departure submission.

Signed:

Name: *C. A. Currie*

Date: *19th Nov 2015*

6. Overseeing Organisation Bridges Branch Comments and Recommendation:

I recommend that the above departure should be accepted / rejected

Signed:

Name:

Date:

7. Overseeing Organisation Recommendation

The above Departure is approved / rejected.

Signed:

Name:

Date:

SUBMISSION FOR VOLUME 1, 2 AND 3 DEPARTURE FROM STANDARDS

DEPARTURE FROM STANDARDS

Name of Works:

Strengthening of End Link Brackets For N.E & S.E Towers

(Bridges and other Highway Structures)

Name of Bridge or Structure: Forth Road Bridge

Structure Reference Number: N/A

OVERSEEING ORGANISATION NAME: Transport Scotland

APPLICATION FOR DEPARTURE FROM STANDARDS – DMRB Vol 1 Section 3 Part 14 BD 37/01

APPLICANT: Fairhurst

PROJECT TITLE: Strengthening of End Link Brackets For N.E & S.E Towers

DEPARTURE No: 004

STRUCTURE REF: Forth Road Bridge

SUBMISSION DATE: 19/11/15

1. List of supporting documentation

Standards: Design Manual For Roads and Bridges (DMRB) Volume 1 Section 3 Part 14 DB 37/01

Drawings: None

Other: Dawe, Peter. *Research Perspectives: Traffic Loading On Highway Bridges*. London: Thomas Telford, 2003. Print;
 Flint and Neill Partnership,. 'Interim Design Standard: Long Span Bridge Loading'. *Transport and Road Research Laboratory Contractor Report 16* (1986): Print.
 Fairhurst. '2010 Bridge Specific Assessment Live Loading + Addendum reports'. (2011)

2. Description of proposed departure

(Include details of DMRB / Eurocode Standards and Clause numbers which are being departed from)

Reduced BSALL load factor from BD37/01 Table 1. The characteristic BSALL loading was adopted for design, this load being derived by multiplying the nominal BSALL loading by 1.2.

3. Designer / Assessor justification

(Include reasons why existing DMRB / Eurocode Standards are inappropriate)

The assessment of the links was initially undertaken at the ultimate limit state in accordance with the standards. For load combinations involving dead plus BSALL this involves applying a factor of 1.5 to the nominal. We understand from literature that in the derivation of the full HA loading detailed in BD 37 at the ultimate limit state loading would only occur once in every 200,000 years, representing an extremely improbable occurrence. The partial factor of 1.5 was determined using engineering judgement as at the time of the code being developed no statistical data was available. The application of a factor of 1.5 significantly lowers the probability that the derived loading will be realised from that assumed in the original derivation based on actual traffic data on the Forth Bridge.

The probability that these loadings occur is reduced further once the new Queen Ferry Crossing opens and traffic is diverted to the new bridge.

The aim of the proposed strengthening works as agreed with FETA was to reduce the level of risk associated with the

4. Cost implications

(Include an estimate of cost savings to Transport Scotland as well as the effect on future maintenance costs)

4.1. Construction costs

Adopting standard loading and load factors for the assessment of the bridge and design of strengthening works will lead to significant works across the bridge structure to achieve code compliance. Reducing the load factor for the bridge reduces the extent of interventions required. The approach proposed by this departure is considered a pragmatic response to the assessed structural issues

4.2. Maintenance costs

NA

5. Applicant design of the Works Team Leader Declaration:

I declare that reasonable professional skill and care have been exercised in the preparation of this Departure submission.

Signed:

Name: C.A. CLARK

Date: 19TH Nov 2015

6. Overseeing Organisation Bridges Branch Comments and Recommendation:

I recommend that the above departure should be accepted / rejected

Signed:

Name:

Date:

7. Overseeing Organisation Recommendation

The above Departure is approved / rejected.

Signed:

Name:

Date:

SUBMISSION FOR VOLUME 1, 2 AND 3 DEPARTURE FROM STANDARDS

DEPARTURE FROM STANDARDS

Name of Works:

Strengthening of End Link Brackets For N.E & S.E Towers

(Bridges and other Highway Structures)

Name of Bridge or Structure: Forth Road Bridge

Structure Reference Number: N/A

OVERSEEING ORGANISATION NAME: Transport Scotland

APPLICATION FOR DEPARTURE FROM STANDARDS – DMRB Vol 1 Section 3 Part 14 BD 37/01

APPLICANT: Fairhurst

PROJECT TITLE: Strengthening of End Link Brackets For N.E & S.E Towers

DEPARTURE No: 005

STRUCTURE REF: Forth Road Bridge

SUBMISSION DATE: 19/11/15

1. List of supporting documentation

Standards: Design Manual For Roads and Bridges (DMRB) Volume 1 Section 3 Part 14 DB 37/01
Design Manual For Roads and Bridges (DMRB) Volume 1 Section 3 Part 14 DB 37/88

Drawings: None

Other: None

2. Description of proposed departure

(Include details of DMRB / Eurocode Standards and Clause numbers which are being departed from)

Reduced max wind gust speed of 50mph from BD37/88 Table clause 5.3. Calculating strictly in accordance with BD 37/88 then combinations comprising wind and live load would be based on a maximum wind gust speed of 78mph

3. Designer / Assessor justification

(Include reasons why existing DMRB / Eurocode Standards are inappropriate)

Where wind loading is applied in conjunction with live loading the wind load is based on a reduced maximum wind gust speed of 50mph and applied in accordance with BD37/88. The application of the wind loading is based on BD 37/88 as it allows for the greater loaded lengths considered in the assessment. The approach taken in BD 37/01 is different and the standard states that it is limited to spans up to 200m in length i.e. half the length of a side span of the Forth Road Bridge.

The load factors quoted in Table 1 of BD 37/01 will be adopted for the assessment. 50mph gust speed is based on the operational procedures which the Forth Road Bridge have in place under high wind situations. At wind speeds 50mph and above the Forth Road Bridge restrict traffic to cars and light vans. In this situation normal traffic loading represented by BSALL will not be achieved.

4. Cost implications

(Include an estimate of cost savings to Transport Scotland as well as the effect on future maintenance costs)

4.1. Construction costs

Adopting standard loading for the assessment of the bridge and design of strengthening works will lead to significant works across the bridge structure to achieve code compliance. Reducing the load factor for the bridge reduces the extent of interventions required. The approach proposed by this departure is considered a pragmatic response to the assessed structural issues

4.2. Maintenance costs

NA

5. Applicant design of the Works Team Leader Declaration:

I declare that reasonable professional skill and care have been exercised in the preparation of this Departure submission.

Signed:

Name: C. A. Currie

Date: 15th Nov 2015

6. Overseeing Organisation Bridges Branch Comments and Recommendation:

I recommend that the above departure should be accepted / rejected

Signed:

Name:

Date:

7. Overseeing Organisation Recommendation

The above Departure is approved / rejected.

Signed:

Name:

Date: