FORTH ROAD BRIDGE

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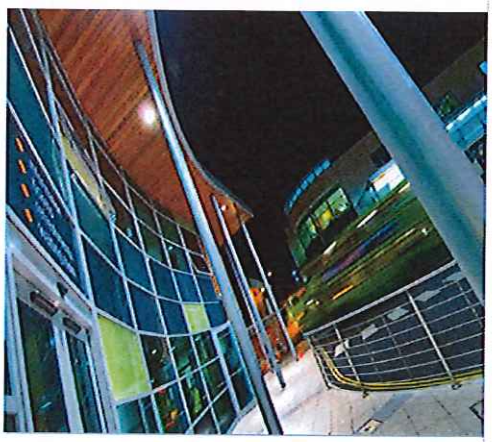
Strengthening of End Link Brackets

Approval in Principle
July 2014



FAIRHURST

FAIRHURST

CONTROL SHEET

CLIENT: Forth Estuary Transport Authority

PROJECT TITLE: Forth Road Bridge -
Strengthening of End Link Brackets

REPORT TITLE: Approval in Principle

PROJECT REFERENCE: 79866C

Issue and Approval Schedule:

ISSUE 1 DRAFT	Name	Signature	Date
Prepared by			04/0/2013
Reviewed by	C Clark		04/0/2013
Approved by	C Clark		04/0/2013

Revision Record:

Issue	Date	Status	Description	By	Chk	App
01	13-Dec-13	Approval	Updated for Cat. III Check Certification. Changes indicated in the margin.			
02	30-Jan-14	Approval	Minor amendments. Changes indicated in the margin.			
03	03-Feb-14	Approval	Minor amendments. Changes indicated in the margin.			
04	18 July 14	Approval	SOV information added following completion of supplementary report			

This report has been prepared in accordance with procedure OP/P03 of Fairhurst's Quality Assurance System.

FAIRHURST

Date – 03 February 2014

APPROVAL IN PRINCIPLE

Name of Project: Forth Road Bridge – Strengthening of End Link Brackets

Name of Bridge: Forth Road Bridge.

Structure Ref No.: Not Applicable.

1 HIGHWAY DETAILS

1.1 Type of highway

Dual carriageway

1.2 Permitted traffic speed

50 mph (80 kph)

1.3 Existing restrictions

FETA impose traffic restrictions which limit the type of vehicles which can cross the bridge when the wind gust speed exceeds a pre-set level as determined by FETA.

2 SITE DETAILS

2.1 Obstacle crossed

Firth of Forth

3 PROPOSED STRUCTURE

3.1 Description of Structure and design working life

The Forth Road Bridge spans the Firth of Forth and carries a non-classified road linking the A90 between Fife and Lothian. The bridge itself consists of three distinct sections, two approach viaducts and a suspension bridge which forms the main section of the structure. The bridge carries two carriageways 7.3m wide and 2 footway/cyclepaths 4.6m wide.

The stiffening truss is connected to the main tower through a link member which is attached to the bottom chord of the truss and to the support brackets cantilevered from the main towers. The bracket web plate is formed from a single mild steel plate 38.1mm (1.5ins) thick. The length of

the plate is such that it extends into the outer cell of the main tower through slots in the tower main plates and stiffeners. The bracket plate external to the tower is provided with narrow flanges top and bottom which extend from the face of the tower to 457mm from the centre of the pin.

The bracket is welded to the outer face of the main tower with a continuous fillet weld provided either side of the bracket plate with unequal leg lengths of 7.9mm (5/16ins) and 11.1mm (7/16ins). There is no weld provided on the inner face of the main tower plate. Within the main tower outer cell the bracket plate is welded to the vertical stiffeners to the main tower plates. The welds between the inner stiffeners and bracket plate are intermittent filet welds with unequal leg lengths of 7.9mm (5/16ins) by 11.1mm (7/16ins). The original fabrication detail both as a 102mm (4ins) hit and 102mm (4ins) miss weld with a net length of weld of 610mm (2ft).

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 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.

3.2 Structural type

For details of the connection and the proposed strengthening works reference should be made to cl. 3.1 above.

3.3 Foundation type

Not Applicable.

3.4 Span arrangements

The existing span arrangement will be retained.

3.5 Articulation arrangements

The articulation arrangement between the main tower and stiffening truss will be maintained as per the existing detail.

3.6 Classes and levels

Not Applicable. The works are improvements to reduce the calculated overstress indices determined at assessment stage. As such the strengthening works have been designed on the basis of the most recent version of BS 5400 as the assessment standards are based on the principles of BS 5400.

3.7 Road Restraint System Type

Not Applicable.

3.8 Proposed arrangements for maintenance and inspection assessment

Given the nature of the works which involve welding to existing steelwork it is recommended that as a minimum regular inspection of the brackets following completion of the works is taken at 3 month intervals for the first year after completion of the works. Inspection cycles beyond this period will be based on the findings.

3.8.1 Traffic Management

No specific arrangements for traffic management will be required to undertake the regular maintenance inspection. However, carriageway closure will be required for maintenance works, should welding of any components be required.

3.8.2 Access

Existing access provision within the main tower legs will be used to gain access to the tower portion which the bracket is located. Additional access equipment may be required to gain access to particular brackets depending on location.

Inspection of the external parts of the tower brackets and the end link members will be gained by a rope access or Bosun's chair.

3.9 Environment and Sustainability

Not applicable. The strengthening works are considered improvement works.

3.10 Materials and Finishes

3.10.1 Materials

All new steel plates will be manufactured from steel complying with BS EN 10025-3:2004. The grade of steel shall be S355 NL.

3.10.2 Finishes

All new steel plates will be located internally in the main tower and will have a protective paint system applied in accordance with Specification for Highway Works to match the current systems used inside the tower.

3.11 Risks and hazards considered for design, execution, maintenance and demolition

Working at height
Working with moving structure/equipment
Work adjacent to live traffic
Working within a confined space
Hot working
Lifting operations
Difficult access
Manual handling
Paint removal (existing internal paint systems from original construction comprise lead based paints) – Dust/Chemical residue
Effect of dead and live loading on sequence of welding critical welds.

3.12 Estimated Cost of proposed structure with other structural forms considered (including where appropriate proprietary manufactured structure), and the reasons for their rejection (including comparative whole life costs with dates of estimates)

The estimated cost for the strengthening works is approximately £400,000. This includes costs for NDT testing of the existing main tower plates.

3.13 Proposed arrangements for construction

3.13.1 Construction of the Structure

Access will require to be provided by the Contractor to reach the work fronts The Contractor's method of working will also require to take account of the presence of lead based paints to the interior surfaces of the existing main tower.

The fabrication and construction of the works shall be generally in accordance with the requirements of BS 5400 Part 6.

3.13.2 Traffic management

To ensure that the stresses due to the live loads are distributed/shared between the new and existing welds, traffic management will be required for the following operations:

- 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.

The traffic management envisaged will be single carriageway closures.

3.13.3 Service diversions

Not applicable as services are not present in the outer cells of the main tower.

3.13.4 Interface with existing structures

The proposed works are to strengthen the existing truss end link connection. Therefore stresses will be checked in the existing plates to ensure that the allowable design stresses are not exceeded.

4 DESIGN CRITERIA

4.1 Actions

4.1.1 Permanent actions

The following permanent actions will be considered:

- Dead loads representing the weight of the steel and concrete structural members forming the bridge and,
- Superimposed dead loads representing the weight of all other materials permanently present on the bridge. Typically these will be surfacing on the carriageways and footways and the weight of services

The calculated dead load of the structure is detailed in the report W. A. Fairhurst & Partner's report, Evaluation of the Current Self Weight of the Suspended Structure 2006.

4.1.2 Snow, Wind and Thermal actions

Wind loads acting on the stiffening trusses and deck structure will be based on the results of wind tunnel testing. Refer to the Wind Tunnel Testing of Deck Structure report by the University of Glasgow dated April 2006. This loading replaces the wind loading given in Clause 5.3 of BD 37. The application of the wind loading will be based on BD 37/88 which allows for the greater loaded lengths considered in the assessment. The load factors quoted in Table 1 of BD 37/88 will be adopted for the assessment.

Wind load acting on the main towers will be based on the results of wind tunnel testing undertaken for the proposed design of the towers for Humber Suspension Bridge. Refer to the National Physical Laboratory Report, A Further Aerodynamic Investigation for the Proposed Humber Suspension Bridge dated June 1972.

Where wind loading is applied in conjunction with live loading the wind load is based on a reduced maximum wind gust speed of 50mph. This 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.

4.1.3 Actions relating to normal traffic under AW regulations and C&U regulations

The live loading due to vehicular traffic will be based on the 2010 Bridge Specific Assessment Live Loading (BSALL) with a 1 in 10 year return period as detailed in the addendum report by W. A. Fairhurst & Partners dated 9th February 2011.

The use of a reduced return period has been agreed with the Forth Road Bridge and is considered appropriate on the basis that a new Forth Crossing is being constructed and that permitted loading on

the existing structure will be limited following opening of the new crossing.

The lane factors applied to the Bridge Specific Assessment Live loading will be those stated in the 2010 BSALL report by W.A. Fairhurst & Partners dated 9th February 2011.

4.1.4 Actions relating to General Order Traffic under STGO regulations

HB loading will not considered acting in combination with Bridge Specific Live Loading.

4.1.5 Footway or footbridge variable actions

Footway loading applied in conjunction with the BSALL loading will be the Bridge Specific Footway Live Loading (BSFLL) as detailed in the report by W.A. Fairhurst & Partners dated June 2006.

4.1.6 Actions relating to Special Order Traffic, provision for an exceptional abnormal indivisible loads including location of vehicle track on deck cross section

Abnormal or special order traffic has not been considered. The Forth Road Bridge manage abnormal or special order traffic and recent work undertaken with the Forth Road Bridge has shown that the normal range of loading is less onerous than that calculated due to the reduced BSALL noted in cl. 4.1.3.

The effects of 250T SOV crossing the bridge have been assessed in Fairhurst Truss End Link Assessment Supplementary Report dated 27th March 2014 and the conclusions of this report will be taken into account.

Where an exceptional loading is proposed to cross the structure the Forth Road Bridge review these applications on a case by case basis.

4.1.7 Accidental actions

Not Applicable.

4.1.8 Action during construction

Not Applicable.

4.1.9 Any special action not covered above

Not Applicable.

4.2 Heavy or high load route requirement and arrangement being made to preserve the route, including any provision for future heavier loads or future widening.

Not Applicable.

4.3 Minimum headroom provided

Not Applicable.

4.4 Authorities consulted and any special conditions required

Forth Estuary Transport Authority: None.

4.5 Standard and documents listed in the Technical Approval Schedule

See Appendix A.

4.6 Proposed departures from Standards given in 4.5

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.

A reduced load factor γ_{fl} of 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.

Adoption of the Bridge Specific Assessment Live Loading based on a reduced return period and Bridge Specific Footway Live Loading as detailed in cl. 4.1.3.

Clause 6.5.1.2 of BD37/01 Reductions in Intensity of Footway loading. Where two footways are loaded the loading on each footway has been reduced to 0.5 of the value calculated from Clause 6.5.1.1. Where only one footway is loaded then no reductions in intensity are applied.

Where wind loading is applied in conjunction with live loading the wind load is based on a reduced maximum wind gust speed of 50mph. This 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.

4.7 Proposed methods of dealing with aspects not covered by standards in 4.5

Based on the loading criteria stated above the strengthening works have been designed for a maximum loading of 1.946MN per link bracket due to combination of Dead, BSALL based on 1 in 10 year return period and BSFLL.

The combination of loading including wind load was found to be less critical.

5 STRUCTURAL ANALYSIS

5.1 Methods of analysis proposed for superstructure, substructures & foundations

The loads in the truss end links will be determined using a global model of the bridge (refer to diagram provided in Appendix D). Finite element structural analysis software LUSAS will be used for the global modelling.

Hand calculations will be undertaken to determine the loads in the support bracket and welds.

The strengthening works to the tower plate stiffeners will be determine on a basis of providing sufficient additional area to allow redistribution of load when the stiffeners are partially removed.

5.2 Description and diagram of idealised structure to be used for analysis

The bridge will be modelled as a 3D frame with each structural member represented by a line beam element in the computer model. The arrangement of the computer model to be used is shown in (refer to diagram provided in Appendix D). The connections between stiffening truss members will be considered as being rigid.

The supports from the side tower to the stiffening truss and deck will be modelled by providing structural support points with rotational releases to represent the articulation of the structure.

Rotational and translation constraints between elements will be used to model the connections of the stiffening truss to the main towers where the use of line beams is not appropriate.

5.3 Assumptions intended for calculation of structural element stiffness

Gross section properties shall be used for the analysis. Section properties to be used in the design will be determined in accordance with relevant British Standards.

Steel strengths for the original main tower sections are based on the following:

High tensile plates (Main plate sections forming the tower legs including cell cover plates) – BS 968: 1943 Type A.

Mild steel plates and sections (all other plates such as link brackets, diaphragm plates and stiffeners) – BS 15: 1948.

5.4 Proposed range of soil parameters to be used in the design of earth retaining elements

Not applicable

6 GEOTECHNICAL CONDITIONS

6.1 Acceptance of recommendations of the Geotechnical Design Report to be used in the design and reasons for any proposed changes.

Not Applicable

6.2 Summary of design for highway structure in the Geotechnical Design Report.

Not Applicable

6.3 Differential settlement to be allowed for in design of the structure:-

Not Applicable

6.4 If the Geotechnical Design Report is not yet available, state when the results are expected and list the sources of information used to justify the preliminary choice of foundations

Not Applicable

7 CHECKING

7.1 Proposed Category and Design Supervision Level

Category 3

7.2 If Category 3, name of proposed Independent Checkers

AECOM

7.3 Erection proposals or temporary works for which Types S and P Proposals will be required, listing structural parts of the permanent structure affected with reasons

Not Applicable

8 DRAWINGS AND DOCUMENTS

8.1 List of drawings (including numbers) and documents accompanying the submission

Drawings referred to below are provided in Appendix B.

79866/11 - Rev A	General arrangement of Existing Main Tower Legs Fourth Portion Sheet 1 of 2
79866/12 - Rev A	General arrangement of Existing Main Tower Legs Fourth Portion Sheet 2 of 2
79866/13 - Rev B	Proposed Strengthening Works Assembled Sheet 1 of 2
79866/14 - Rev B	Proposed Strengthening Works Assembled Sheet 2 of 2
79866/15 - Rev B	Proposed Strengthening Works Construction Sequence Sheet 1 of 2
79866/16 – Rev A	Proposed Strengthening Works Construction Sequence Sheet 2 of 2

A list of record drawings for the existing structure which the construction drawings will be based is provided in Appendix C.

9 THE ABOVE IS SUBMITTED FOR ACCEPTANCE

Signed: .....

Name: Colin A. Clark
(DESIGN TEAM LEADER)

Engineering Qualifications: BSc CEng MICE

Name of Organisation: **FAIRHURST**

Date: .....

10 THE ABOVE IS AGREED SUBJECT TO THE AMENDMENTS AND CONDITIONS SHOWN BELOW

Signed:

Name: BARRY R COLFORD

Position held Chief Engineer & Bridgemaster

Engineering Qualifications BSc CEng MICE

TAA Forth Estuary Transport Authority

Date: 04 August 2014

Appendix A

Relevant Documents and Standards used in the Design

Technical Standards Schedule

It is the responsibility of the complier of the AIP and/or the design or check certificate complier to ensure that the Standards, references and clauses used, including amendments and corrigenda are relevant and current at the Base Date.

Documents in *italics* are under preparation at the time of preparation of this document.

Schedule of Documents Relating to Design of Highway Bridges ad Structures using UK National Standards

BRITISH STANDARDS (HMSO publications)		
~~BS 5268~~	~~Part 2: 1996~~	~~Structural Use of Timber~~
BS 5400		Steel, Concrete and Composite Bridges
	Part 1: 1988	General Statement, see BD 15
	Part 2: 1978	Specification for Loads, see BD 37/01
	Part 3: 2000	CP for design of steel bridges, see BD 13/04
	~~Part 4: 1990~~	~~CP for design of concrete bridges, see BD 24/92~~
	~~Part 5: 1979~~	~~CP for design of composite bridges, see BD 16/82~~
	Part 6: 1999	Specification for materials and workmanship, steel
	~~Part 9: 1983~~	~~Bridge Bearings, see BD 20/92~~
	~~Part 10: 1980~~	~~CP for fatigue, see BD 9/81~~
~~BS 5628~~		~~Code of Practice for Use of Masonry~~
	~~Part 1: 1982~~	~~Structural use of Unreinforced Masonry~~
	~~Part 2: 1995~~	~~Structural Use of Reinforced and Prestressed Masonry, see BD 41/97~~
	~~Part 3: 1985~~	~~Materials and Components, Design and Workmanship, see BD 41/97~~
~~BS 5930~~	~~1999~~	~~Code of Practice for Site Investigations~~
~~BS 6031~~	~~1981~~	~~Code of Practice for Earthworks~~
~~BS 8002~~	~~1994~~	~~Earth Retaining Structures~~
~~BS 8004~~	~~1986~~	~~Foundations, see BD 32/88~~
~~BS 8118~~		~~Structural Use of Aluminium~~
	~~Part 1: 1991~~	~~Code of Practice for design~~
	~~Part 2: 1991~~	~~Specification for Materials, Workmanship and Protection~~
~~BS EN 1317-1~~	~~1998 Road Restraint Systems – Part 1~~	~~Terminology and general criteria for test methods~~

BRITISH STANDARDS (HMSO publications)		
~~BS EN 1317-2~~	~~1998 Road Restraint Systems – Part 2~~	~~Performance classes, impact test acceptance criteria and test methods for safety barriers~~
~~BS EN 1317-3~~	~~2000 Road Restraint Systems – Part 3~~	~~Performance classes, impact test acceptance criteria and test methods for crash cushions~~
~~ENV 1317-4~~	~~2002 Road Restraint Systems – Part 4~~	~~Terminals and transitions~~

Execution Standards	
BS EN 1090-1:2009	Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components
BS EN 1090-2:2008	Execution of steel structures and aluminium structures – Part 2: Technical requirements for the execution of steel structures
~~BS EN 1090-3:2008~~	~~Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures~~
~~EN 13670~~	~~Execution of concrete structures~~

Miscellaneous
~~Circular Roads No 61/72 – Routes for heavy and high abnormal loads (refer to the website http://www.ocdal.com)~~
Traffic Management Act 2004
Construction (Design and Management) Regulations 2007

The Manual of Contract Documents for Highway Works (MCDHW) *(Designers should consult and agree with the TAA on the version of MCDHW to be used with Eurocode design)*
Volume 1: Specification for Highway Works
Volume 2: Notes for Guidance on the Specification for Highway Works
Volume 3: Highway Construction Details

The Design Manual for Roads and Bridges (DMRB) **General Requirements, Standards (GD Series)**	
GD 01	Introduction to the Design Manual for Roads and Bridges (DMRB)
GD 02	Quality Management Systems for Highway Design
~~BA 26/94~~	~~Expansion Joints for use in Highway Bridge Decks~~
~~BA 28/92~~	~~Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures~~
~~BA 36/90~~	~~The use of permanent formwork~~
~~BA 41/98~~	~~The Design and Appearance of Bridges~~
~~BA 42/96~~	~~The Design of Integral Bridges~~
~~BA 44/96~~	~~Assessment of Concrete Highway Bridge and Structures~~
~~BA 47/99~~	~~Waterproofing and Surfacing of Concrete Bridge Decks~~
~~BA 56/10~~	~~The Assessment of Steel Highway Bridges and Structures~~
BA 57/01	Design for Durability
~~BA 59/94~~	~~Design of Highway Bridges for Hydraulic Action~~
~~BA 67/96~~	~~Enclosure of Bridges~~
~~BA 68/97~~	~~Crib Retaining Walls~~
~~BA 72/03~~	~~Maintenance of Road Tunnels~~
~~BA 74/06~~	~~Assessment of Scour at Highway Bridges~~
~~BA82/00~~	~~Formation of Continuity Joints in Bridge Decks~~
~~BA 84/02~~	~~Use of Stainless Steel Reinforcement in Highway Structures~~
~~BA 85/04~~	~~Coatings for Concrete Highway Structures & Ancillary Structures~~
~~BA 92/07~~	~~The Use of Recycled Concrete Aggregates in Structural Concrete~~
~~BD 7/01~~	~~Weathering Steel for Highway Structures~~
~~BD 10/97~~	~~Design of Highway Structures in Areas of Mining Subsidence~~
~~BD 12/01~~	~~Design of Corrugated Steel Buried Structures with Spans greater than 0.9 metres and up to 8.0 metres~~
~~BD 20/92~~	~~Bridge Bearings, Use of BS 5400: Part 9: 1983~~
~~BD21/01~~	~~The Assessment of Highway Bridges and Structures~~
~~BD 29/04~~	~~Design Criteria for Footbridges~~
~~BD 33/94~~	~~Expansion Joints for use in Highway Bridge Decks~~

The Design Manual for Roads and Bridges (DMRB) Bridges and Structures, Advice Notes (BA Series)	
~~BD 35/06~~	~~Quality Assurance Scheme for Paints and Similar Protective Coatings~~
~~BD 36/92~~	~~Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures~~
BD 37/01	Loads for Highway Bridges (for defining an HB rating only)
~~BD41/97~~	~~Reinforced clay brickwork retaining walls of pocket type and grouted cavity type construction – use of BS 5628:Part 2:1995~~
~~BD 43/03~~	~~The impregnation of Reinforced and Prestressed concrete Highway Structures using Hydrophobic Pore Lining Impregnants~~
~~BD 45/93~~	~~Identification Markings of Highway Structures~~
~~BD 47/99~~	~~Waterproofing and Surfacing of Concrete Bridge Decks~~
~~BD 51/98~~	~~Portal and Cantilever Signs/Signal Gantries~~
~~BD 53/95~~	~~Inspection and Records for Road Tunnels~~
BD 57/01	Design for Durability
~~BD 62/07~~	~~As built, Operational and Maintenance Records for Highway Structures~~
~~BD 63/07~~	~~Inspection of Highway Structures~~
~~BD 65/97~~	~~Design Criteria for Collision Protection Beams~~
~~BD 67/96~~	~~Enclosure of Bridges~~
~~BD 68/97~~	~~Crib Retaining Walls~~
~~BD 70/03~~	~~Strengthened/reinforced Soils and other Fills for Retaining Walls and Bridge Abutments. Use of BS 8600:1995 incorporating amendment no. 1 (Issue 2 March 1999)~~
~~BD 78/99~~	~~Design of Road Tunnels~~
~~BD 82/00~~	~~Design of Rigid Buried Pipes~~
~~BD 90/05~~	~~Design of FRP Bridges and Highway Structures~~
~~BD 91/04~~	~~Unreinforced Masonry Arch Bridges~~
~~BD 94/07~~	~~Design of Minor Structures~~

The Design Manual for Roads and Bridges (DMRB) Traffic Engineering and Control, Standards and Advice Notes (TD and TA Series)	
~~TD 9/93~~	~~Highway Link Design~~
~~TD 19/06~~	~~Requirement for Road Restraint Systems~~
~~TD 27/05~~	~~Cross Sections and Headroom~~
~~TD 36/93~~	~~Subways for Pedestrians and Cyclists, Layout and Dimensions~~
~~TD 89/08~~	~~Use of Passively Safe Signposts, Lighting Columns & Traffic Signal Posts to BS EN 12767~~

The Design Manual for Roads and Bridges (DMRB) Highways, Advice Notes (HA Series)	
~~HA 59/92~~	~~Mitigating Against Effects on Badgers~~
~~HA 66/95~~	~~Environmental Barriers – Technical Requirements~~
~~HA 80/99~~	~~Nature Conservation Advice in Relation to Bats~~
~~HA 81/99~~	~~Nature Conservation Advice in Relation to Otters~~
~~HA 84/01~~	~~Nature Conservation and Biodiversity~~
~~HA 97/01~~	~~Nature Conservation Management Advice in Relation to Dormice~~
~~HA 98/01~~	~~Nature Conservation Management Advice in Relation to Amphibians~~

The Design Manual for Roads and Bridges (DMRB) Highways, Standards (HD Series)	
~~HD 22/08~~	~~Managing Geotechnical Risk~~

Transport Scotland Interim Advice Notes	
~~TSIA 22~~	~~Implementation of new reinforcement standards (BS 4449:2005, BS 4482:2005, BS 4483: 2005 and BS 8666:2005)~~
~~TSIA 23~~	~~Implementation of BS8500-1:2006 Concrete – Complementary British Standard To BS EN 206-1~~
~~TSIA 24~~	~~Guidance on implementing results on research on bridge deck waterproofing~~
TSIA 27	Implementation of the Construction (Design and Management) Regulations 2007 and the withdrawal of SD 10/05 and SD 11/05
~~TSIA 31~~	~~Use of Eurocodes for the design of bridges and road related structures~~

Appendix B

Drawings Accompanying the Submission

Appendix C

List of Record Drawings appropriate to the area of work

Drawings Prepared by Sir William Arrol & Co LTD. Contract - The ACD Bridge Company - Forth Road Bridge Job No 1832/58		
Drawing No.	**Drawing Title**	**Revision**
17	Main Towers.Detail of Centre Box. 4th Portion of Legs.	J
18 Sheet 1	Main Towers.Detail of Outer Boxes. 4th Portion of Legs.	Q
18 Sheet 2	Main Towers. 4th Portion of Legs. Relation of footway Brkts To Roadway Brkts.	-
19	Main Towers.Detail of Cover Plates. 4th Portion of Legs.	G
80	Main Towers. Record of Position and Levels of Link Holes In Suspended Structure Support Brackets As Fabricated.	-

Drawings Prepared by W.A.Fairhurst and Partners Project Title: Forth Road Bridge Joint Board Upgrading of Main Towers. Job No 21511		
Drawing No.	**Drawing Title**	**Revision**
21511/14	Proposed General Arrangement of Tower (N.W &S.E. Legs) Third & Fourth Portions	B
21511/20	Proposed General Arrangement of Tower (S.W &N.E. Legs) Third & Fourth Portions	B

Appendix D

Diagrams of Idealised Structure to be used for Analysis

3-Dimensional View of the FE model of the structure

Figure 1 – Bridge model