FORTH ROAD BRIDGE

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

Approval in Principle

FAIRHURST

FAIRHURST

CONTROL SHEET

CLIENT: **Amey**

PROJECT TITLE: **Forth Road Bridge –
Strengthening of End Link Brackets**

REPORT TITLE: **Approval in Principle**

PROJECT REFERENCE: **109178A**

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Issue & Approval Schedule	ISSUE 1	Name	Signature	Date
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Revision Record	Issue	Date	Status	Description	Signature	
	2	11/09/15	Approval	Minor Amendment as per Amey's comments	By	
					Checked	
					Approved	
	3	26/10/15	Approval	Load case descriptions and drawings added	By	
					Checked	
					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.*

FAIRHURST

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

The bridge operator imposes traffic restrictions which limits the type of vehicles which can cross the bridge when the wind gust speed exceeds a pre-set level as determined by the bridge operator (previously 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

Welding required to be undertaken out with periods of heavy traffic and under free flowing traffic conditions. If this is not possible then carriageway closure will be required.

No specific arrangements for traffic management will be required to undertake the regular maintenance inspection.

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 £200,000. 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

Fairhurst have undertaken a global analysis of the bridge using a 3D finite element model. The actions considered are set out in section 4 below. The results of this analysis in relation to the load in the links will be provided to the checker for the structural assessment of the end link system.

This strengthening work represents the next phase in the strengthening of all the links of the main towers, the previous work being undertaken on the NW Main Tower Leg Links. To maintain a consistent approach for all link strengthening the loadings will be derived and the design undertaken to codes and standards set out in Appendix A and the criteria stated below.

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 37/01 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 with amended lane factors based on calculation from WIM information.

The use of a reduced return period and amended lane factors was previously 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 characteristic values of BSALL loading calculated from the WIM analysis was divided by 1.2 to provide a nominal value for traffic loading. By calculating from a nominal loading then BSALL could be factored in accordance with load combinations in BD 37/01.

4.1.4 Actions relating to General Order Traffic under STGO regulations

HB loading will not be considered to act 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

The effects of a 250T Special Order Vehicle (SOV) has 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.

In the event where the one carriageway is to remain open to normal traffic then the effects of a max 170T SOV has been assessed on the second carriageway.

Other abnormal or special order traffic as set out in BD 86/11 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.

Where an exceptional loading is proposed to cross the structure, these applications will be reviewed 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

Bridge Operator (AMEY): 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 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.

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 for a reduced return period of 1 in 10 years

Bridge Specific Footway Live Loading as detailed in cl. 4.1.5 has been adopted. With reference to 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 and applied in accordance with BD37/88. 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

With reference to the loading criteria stated above the strengthening works have been based on the loading scenarios set out in drawings 1001 to 1004 found in Appendix B only and summarized below

4.7.1 170T SOV + BSALL

Refer to Load Case 1A and 1B on drawing 109178A/1001

When the second carriageway is to remain open to normal traffic the effects of a 170T SOV has been assessed with 2010 BSALL of 100m max loaded length. Longer loaded lengths would increase the loading in the End Link however traffic is controlled by the Bridge operator therefore if a traffic incident occurred where stationary traffic extended further than 100m then the 170T SOV would not be allowed access to the bridge until this incident is cleared and normal traffic flow returns.

The 170T SOV is assumed to remain in the slow lane and is escorted across the bridge where its speed is limited. For this reason the dynamic amplification factor as set out in BD86/11 has not been applied. The overload factor has been included and ULS live load factors in accordance with BD 86/11 adopted. No wind loading has been assessed as the bridge operator restricts abnormal traffic during increased wind situations.

Dead weights have been assessed at ULS with departures as stated in section 4.6.

The loading in the End Links for a 170T SOV and BSALL was 2.993MN.

4.7.2 250T SOV

Refer to Load Case 2A, 2B and 2C on drawings 109178A/1002 and 1003.

A 250T SOV was considered by FETA to be the maximum abnormal vehicle required to cross the bridge. In such events the bridge would be closed to all other traffic and the SOV would be escorted, limiting its speed. No wind loading was considered as the bridge operator restricts abnormal traffic during increased wind situations.

A number of load cases for the 250T SOV were accepted by FETA:

- A SOV travelling in the slow lane where dynamic amplification and overload factor was applied. Safety factors for live and dead loadings at serviceability limit state (SLS). The loading in the End Link was 2.931MN.

- A SOV in the slow lane with the dynamic amplification factor removed but overload factor included. All safety factors at ultimate lime state (ULS). The loading in the End Link was 3.121MN.

- A SOV in the fast lane with dynamic amplification and overload factor included. All safety factors at ultimate lime state (ULS). The loading in the End Link was 2.831MN.

It was accepted that when the bridge was closed to all traffic then an SOV up to 250T should travel in the fast lane only and be escorted.

4.7.3 BSALL

Refer to Load Case 3A and 3B on drawings 109178A/1004.

On lanes 1 and 2, 362m of BSALL has been applied in conjunction with 50m of BSALL on lanes 3 and 4. The BSALL loading was factored by 1.2 from the nominal loading to provide a characteristic value for the assessment which was used for all load cases. This was done to represents the minimum realist loading which the links are likely to be subjected to in the short design period until the new bridge is open to traffic.

2006 Bridge Specific Footway Live Loading was applied for a loaded length of 362m on the footway nearest lane 1. Safety factors were applied in accordance with BD 37/01.

Wind loading of 50mph gust was assessed as part of the combinations of actions and applied in accordance with BD37/88.

Dead weights have been assessed at ULS with departures as stated in section 4.6.

The loading in the End Link with no wind loading was 3.178MN.

The loading in the End Link with wind loading was 3.270MN.

4.7.4. Summary of End Link Loads

Based on the above load combination the loads on the Main Span End Links are summarized in the table below:

Load Case	Load in End Link
170T SOV + BSALL	
LC 1A	**2.993 MN**
LC 1B	2.648 MN
250T SOV	
LC 2A	2.931 MN
LC 2B	**3.121 MN**
LC 2C	2.813 MN
BSALL	
LC 3A	3.187 MN
LC 3B	**3.270 MN**

5 STRUCTURAL ANALYSIS

5.1 Methods of analysis proposed for superstructure, substructures & foundations

Fairhurst have determined the loadings in the truss end link which was determined using a global model of the bridge (refer to diagram provided in Appendix D). Finite element structural analysis software LUSAS was used for the global modelling. The loadings in the end links and towers will be provided by Fairhurst for the check (loadings previously verified by AECOM as part of the Cat III check of the suspended structure of bridge). From the provided loadings, 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 determined 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 used for analysis

The global analysis of the bridge was 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 used is shown in diagram provided in Appendix D. The connections between stiffening truss members was considered as being rigid.

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

Rotational and translation constraints between elements were 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

Arup

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.

109178A / 11	General arrangement of Existing Main Tower Legs Fourth Portion (Sheet 1 of 2)
109178A / 12	General arrangement of Existing Main Tower Legs Fourth Portion (Sheet 2 of 2)
109178A / 13	Proposed Strengthening Works Assembled (Sheet 1 of 2)
109178A / 14	Proposed Strengthening Works Assembled (Sheet 2 of 2)
109178A / 15	Proposed Strengthening Works Construction Sequence (Sheet 1 of 3)
109178A / 16	Proposed Strengthening Works Construction Sequence (Sheet 2 of 3)
109178A / 17	Proposed Strengthening Works Construction Sequence (Sheet 3 of 3)
109178A/1001	Main Span End Link Load Cases (Sheet 1 of 4)
109178A/1002	Main Span End Link Load Cases (Sheet 2 of 4)
109178A/1003	Main Span End Link Load Cases (Sheet 3 of 4)
109178A/1004	Main Span End Link Load Cases (Sheet 4 of 4)

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
(PARTNER)

Engineering Qualifications: BSc CEng MICE

Name of Organisation: **FAIRHURST**

Date: ..... 11th Sept 2015 .....

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

Signed: .....

Name: .....

Position held .....

Engineering Qualifications .....

TAA .....

Date: .....

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~~

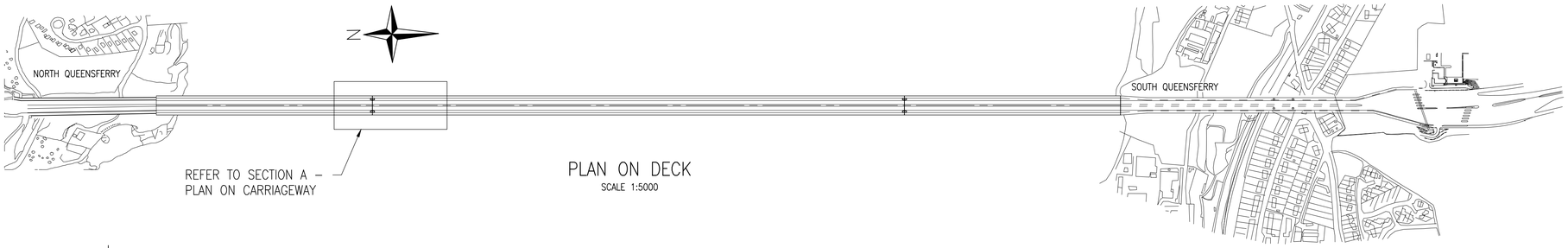
The Design Manual for Roads and Bridges (DMRB) **Highways, Standards (HD Series)**	
~~HD 22/08~~	~~Managing Geotechnical Risk~~

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~~

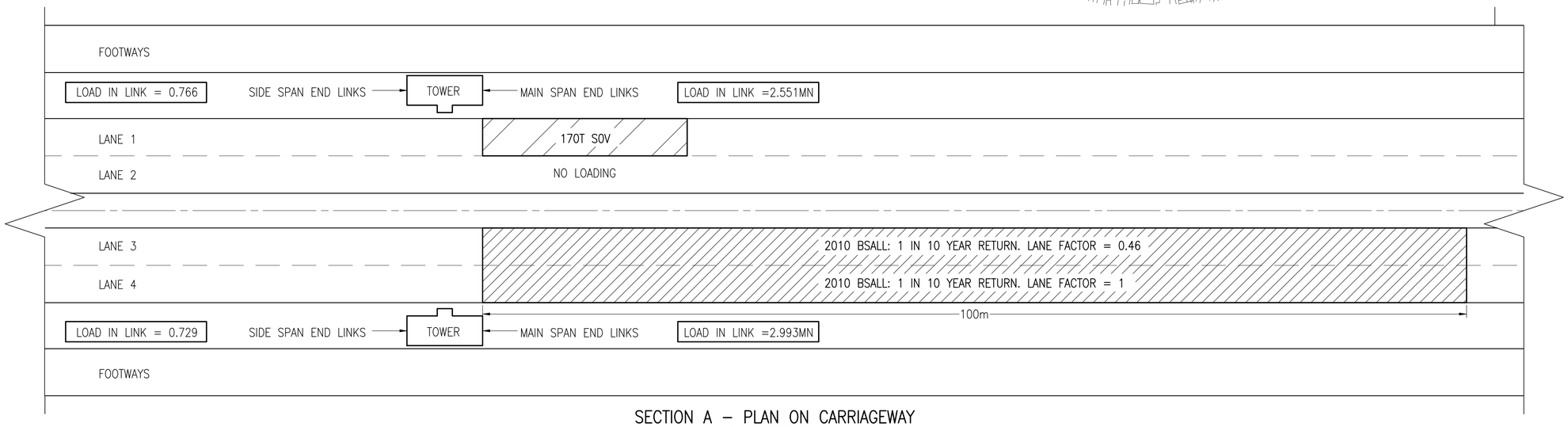
Appendix B

Drawings Accompanying the Submission

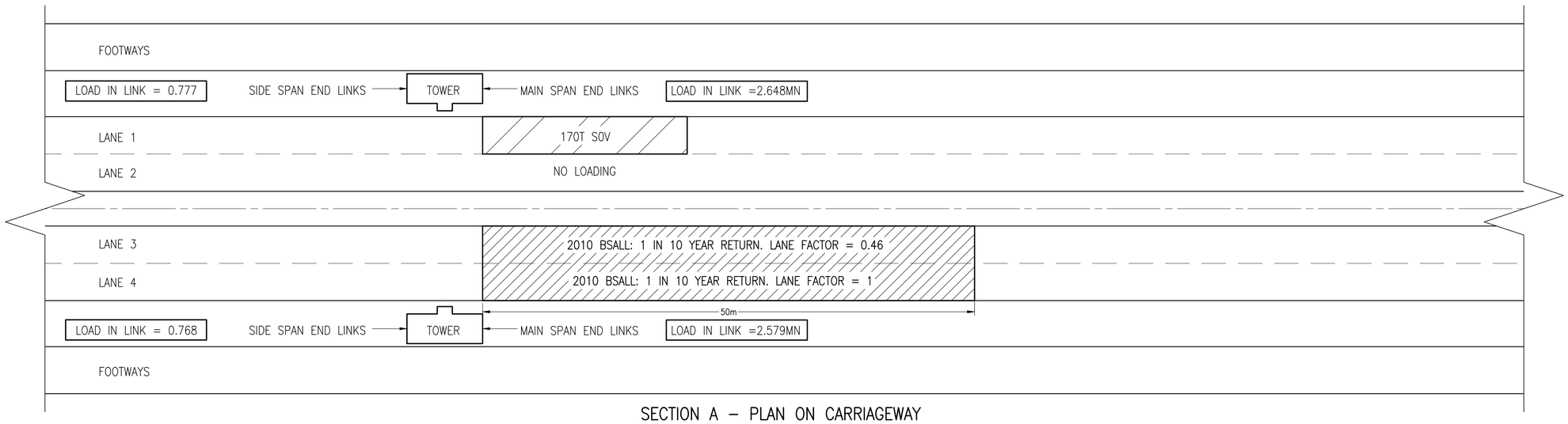
Do not scale from this drawing.



PLAN ON DECK
SCALE 1:5000



SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 1A
N.T.S



SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 1B
N.T.S

Rev.	Date	Description	Drawn	Checked	Approved

Notes:

LOAD CASE 1A

LANE 1: 170T SOV INCLUDES OVERLOAD FACTOR BUT NO DYNAMIC AMPLIFICATION FACTOR. PARTIAL LIVE LOAD FACTOR OF 1.1 IN ACCORDANCE WITH BD 86/11

LANE 2: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC

LANE 3: LOADING IS 46% OF LANE 4 BSALL. THE REDUCED LANE FACTOR IS BASED ON CALCULATIONS FROM WEIGH IN MOTION (WIM) INFORMATION

LANE 4: 2010 BSALL FOR A RETURN PERIOD OF 1 IN 10 YEARS.LOADED LENGTH OF 100m PARTIAL LIVE LOAD FACTOR OF 1.3 TO BD86/11

DEAD WEIGHTS: ULS LOAD FACTOR IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACE LOAD FACTOR OF 1.2

LOAD CASE 1B

LANE 1: 170T SOV INCLUDES OVERLOAD FACTOR BUT NO DYNAMIC AMPLIFICATION FACTOR. PARTIAL LIVE LOAD FACTOR OF 1.1 IN ACCORDANCE WITH BD 86/11

LANE 2: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC

LANE 3: LOADING IS 46% OF LANE 4 BSALL. THE REDUCED LANE FACTOR IS BASED ON CALCULATIONS FROM WEIGH IN MOTION (WIM) INFORMATION

LANE 4: 2010 BSALL FOR A RETURN PERIOD OF 1 IN 10 YEARS. LOADED LENGTH OF 50m PARTIAL LIVE LOAD FACTOR OF 1.3 TO BD 86/11

DEAD WEIGHTS: ULS LOAD FACTOR IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACE LOAD FACTOR OF 1.2

Client: amey / TRANSPORT SCOTLAND

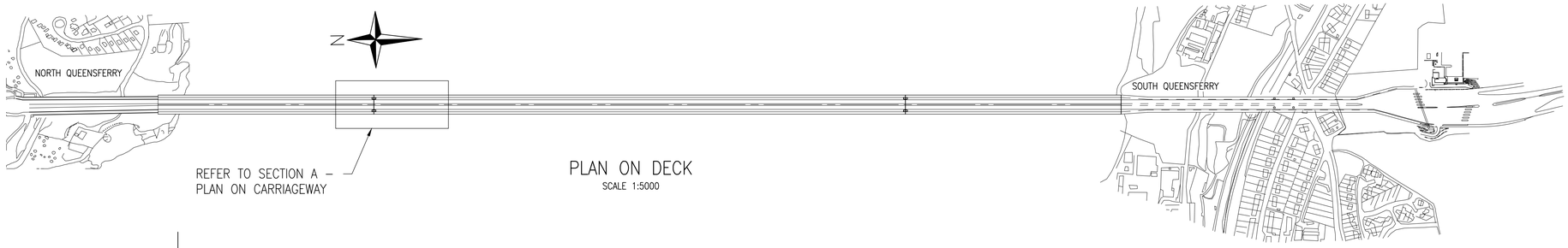
Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title:
MAIN SPAN END LINK LOAD CASES (SHEET 1 OF 4)

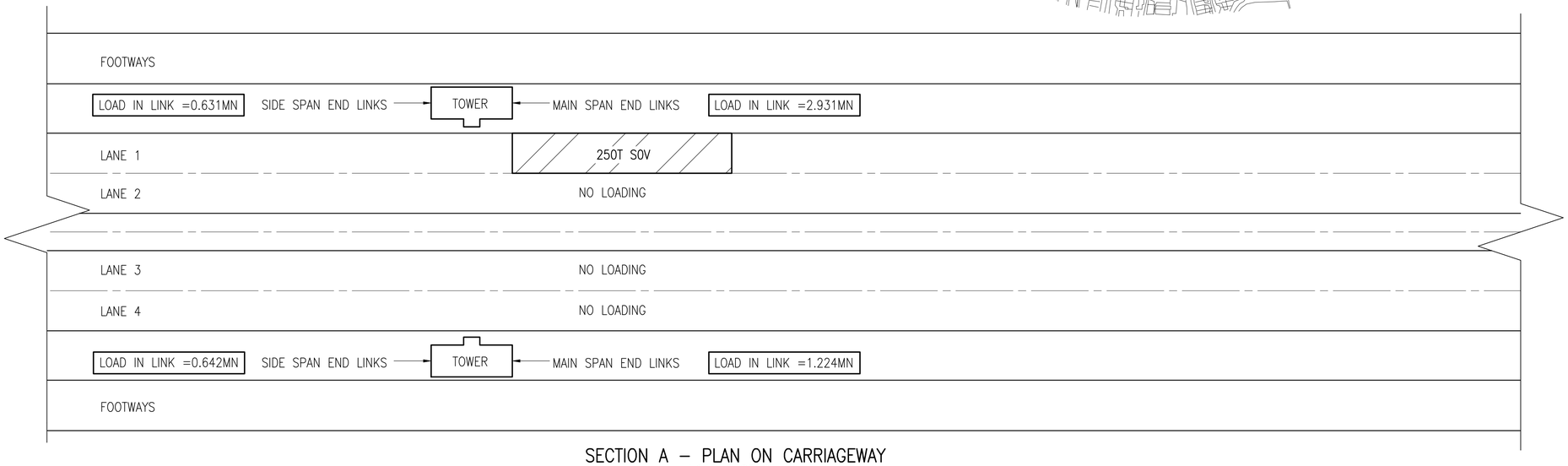
FAIRHURST
225 Bath Street,
GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	FOR APPROVAL	
Drawn: CMcL	Checked: DAJE	Approved: CAC
Date: 23/10/15	Date: 23/10/15	Date: 23/10/15
Drawing No.: 109178/1001		Revision: –

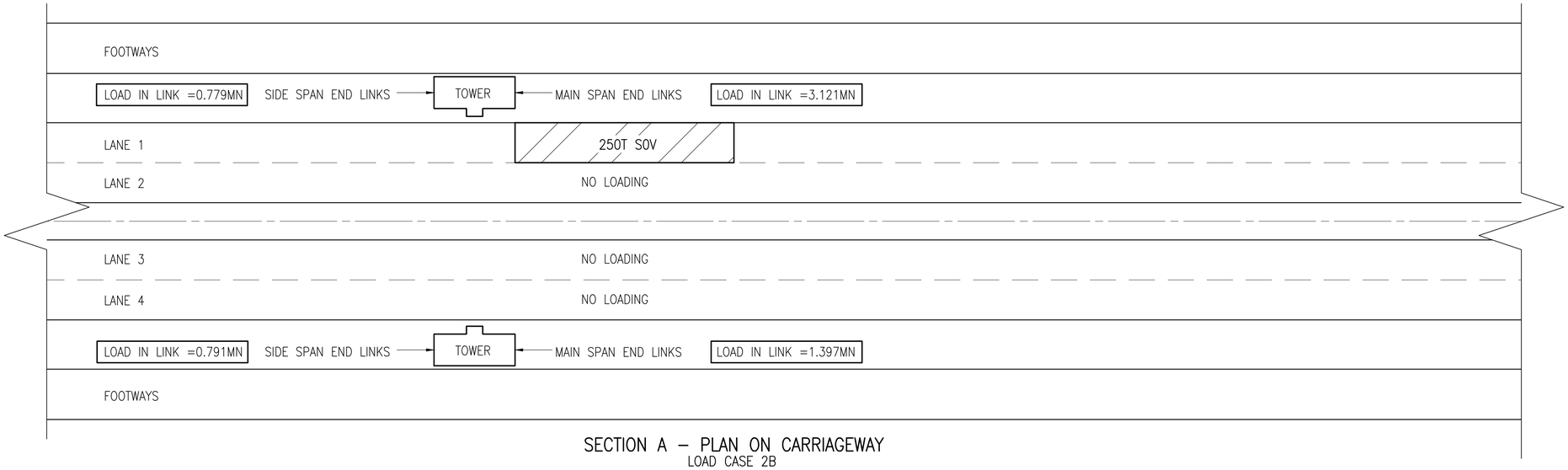
Do not scale from this drawing.



PLAN ON DECK
SCALE 1:5000



SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 2A
N.T.S



SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 2B
N.T.S

Rev.	Date	Description	Drawn	Checked	Approved

Notes:

LOAD CASE 2A:

LANE 1: 250T SOV WITH DYNAMIC AMPLIFICATION FACTOR & OVERLOAD FACTOR IN ACCORDANCE WITH BD86/11. PARTIAL LIVE LOAD FACTORS CONSIDERED AT SERVICEABILITY LIMIT STATE (SLS)
LANE 2: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
LANE 3: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
LANE 4: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
DEAD WEIGHTS: SLS LOAD FACTORS IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACING LOAD FACTOR OF 1

LOAD CASE 2B:

LANE 1: 250T SOV INCLUDES AN OVERLOAD FACTOR BUT NO DYNAMIC AMPLIFICATION FACTOR. PARTIAL LIVE LOAD FACTOR OF 1.1 IN ACCORDANCE WITH BD86/11
LANE 2: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
LANE 3: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
LANE 4: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
DEAD WEIGHTS: ULS LOAD FACTORS IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACING LOAD FACTOR OF 1.2

Client: amey / TRANSPORT SCOTLAND

Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

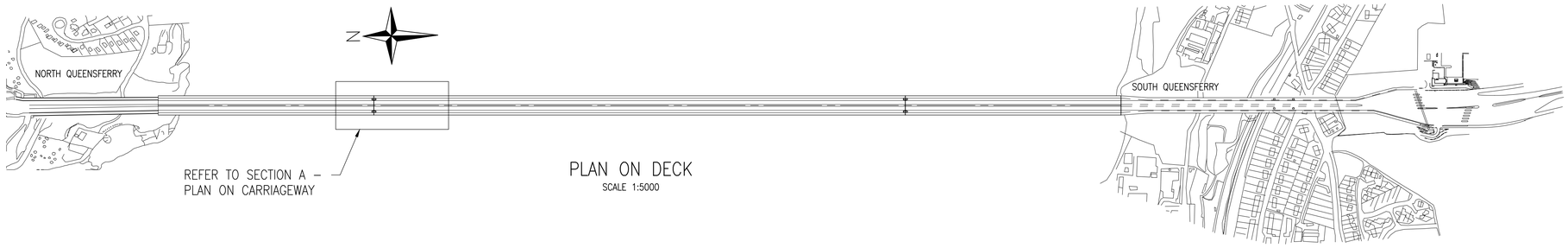
Drawing Title:
MAIN SPAN END LINK LOAD CASES (SHEET 2 OF 4)

FAIRHURST
225 Bath Street,
GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

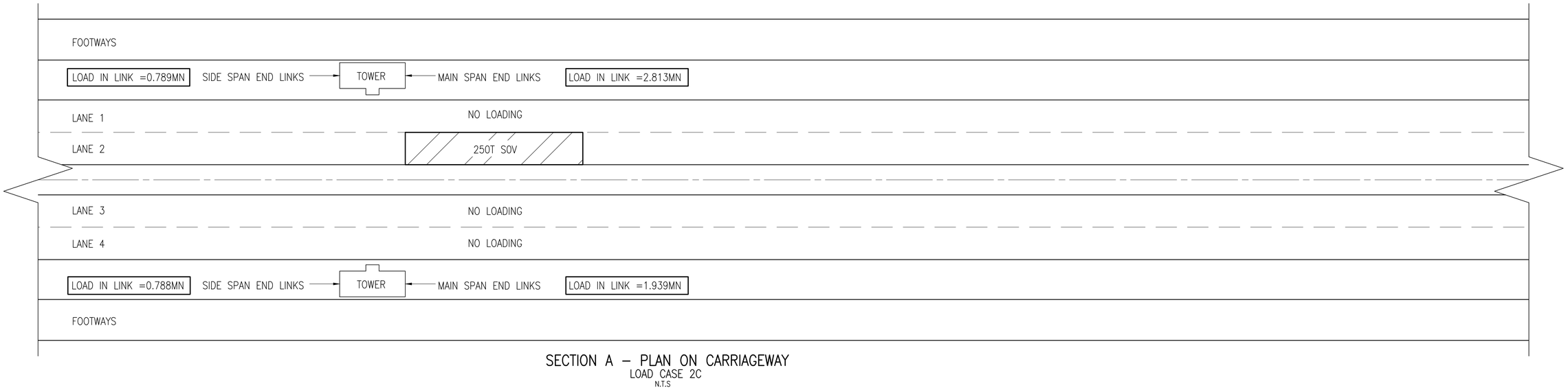
Scale at A1:	Status:	
AS SHOWN	FOR APPROVAL	
Drawn:	Checked:	Approved:
CMcL	DAJE	CAC
Date:	Date:	Date:
23/10/15	23/10/15	23/10/15

Drawing No.: 109178/1002
Revision: –

Do not scale from this drawing.



PLAN ON DECK
SCALE 1:5000



SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 2C
N.T.S

Rev.	Date	Description	Drawn	Checked	Approved

Notes:

LOAD CASE 2C:

LANE 1: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
LANE 2: 250T SOV POSITIONED IN THE FAST LANE WITH A DYNAMIC AMPLIFICATION FACTOR & AN OVERLOAD FACTOR. PARTIAL LIVE LOAD FACTOR OF 1.1 IN ACCORDANCE WITH BD86/11
LANE 3: NO LOADING ON LANE AS CARRIAGEWAY IS CLOSED TO ALL OTHER TRAFFIC
LANE 4: NO LOADING ON LANE CARRIAGEWAY CLOSED TO ALL OTHER TRAFFIC
DEAD WEIGHTS: ULS LOAD FACTORS IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACING LOAD FACTOR OF 1.2

Client: amey / TRANSPORT SCOTLAND

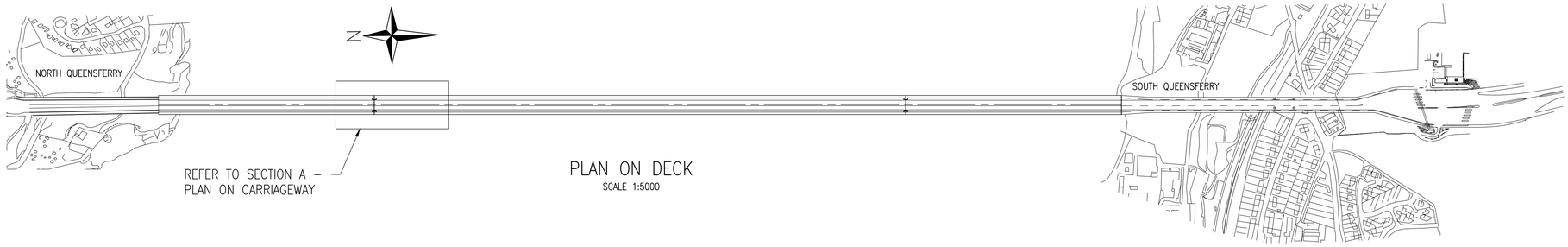
Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title:
MAIN SPAN END LINK LOAD CASES (SHEET 3 OF 4)

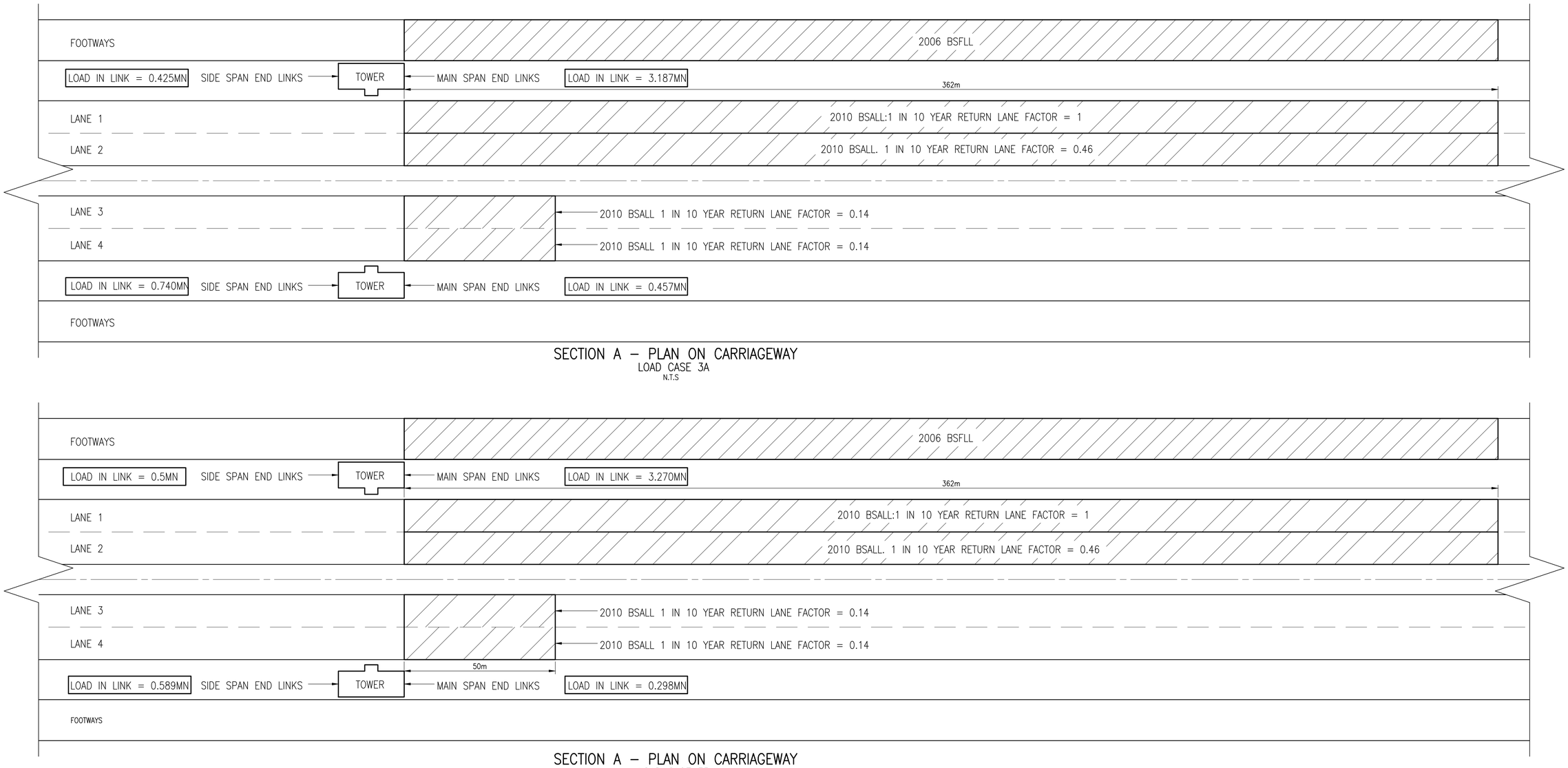
FAIRHURST
225 Bath Street,
GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	FOR APPROVAL	
Drawn:	Checked:	Approved:
CMcL	DAJE	CAC
Date:	Date:	Date:
23/10/15	23/10/15	23/10/15
Drawing No.:		Revision:
109178/1003		–

Do not scale from this drawing.



PLAN ON DECK
SCALE 1:5000



SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 3A
N.T.S

SECTION A – PLAN ON CARRIAGEWAY
LOAD CASE 3B
N.T.S

Rev.	Date	Description	Drawn	Checked	Approved

Notes:

LOAD CASE 3A:

LANE 1: LOADING IS CHARACTERISTIC VALUE OF 2010 BSALL WHERE LOAD FACTOR IS 1.2

LANE 2: LOADING IS 46% OF LANE 1 LOADING. LANE FACTOR BASED ON CALCULATIONS FROM WEIGH IN MOTION (WIM) INFORMATION.

LANE 3/4: LOADING IS 14% OF LANE 1 BSALL FOR AN EQUIVALENT 50m LOADED LENGTH. LANE FACTOR BASED ON CALCULATIONS FROM WEIGH IN MOTION (WIM) INFORMATION.

EAST FOOTWAY: 2006 BSFLL FOR 362m LOADED LENGTH. PARTIAL LIVE LOAD FACTOR OF 1.5 IN ACCORDANCE WITH BD37/01

WEST FOOTWAY: NO FOOTWAY LOADINGS CONSIDERED

3A CONT.

DEAD WEIGHTS: ULS LOAD FACTORS IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACING LOAD FACTOR OF 1.2

LOAD CASE 3B:

LANE 1: LOADING IS CHARACTERISTIC VALUE OF 2010 BSALL WHERE LOAD FACTOR IS 1.2

LANE 2: LOADING IS 46% OF LANE 1 LOADING. REDUCED FACTOR BASED ON CALCULATIONS FROM WEIGH IN MOTION (WIM) INFORMATION.

LANE 3/4: LOADING IS 14% OF LANE 1 BSALL FOR AN EQUIVALENT 50m LOADED LENGTH LANE FACTOR BASED ON CALCULATIONS FROM WEIGH IN MOTION (WIM) I NFORMATION

3B CONT.

EAST FOOTWAY: 2006 BSFLL FOR 362m LOADED LENGTH. PARTIAL LIVE LOAD FACTOR OF 1.5 IN ACCORDANCE WITH BD37/01

WEST FOOTWAY: NO FOOTWAY LOADINGS CONSIDERED

DEAD WEIGHTS: ULS LOAD FACTORS IN ACCORDANCE WITH BD37/01 & BD86/11. SURFACING LOAD FACTOR OF 1.2

WIND LOADING: MAXIMUM WIND GUST SPEED OF 50MPH APPLIED IN ACCORDANCE WITH BD37/88

Client: amey / TRANSPORT SCOTLAND

Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

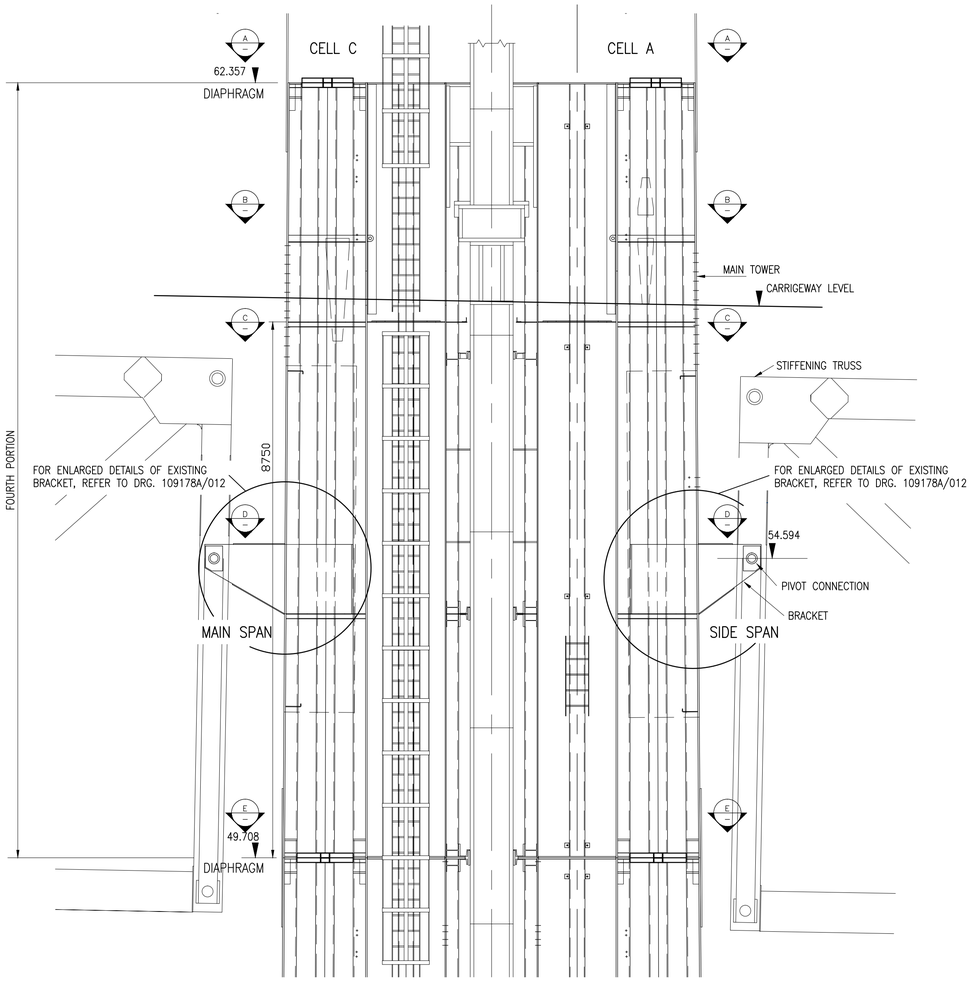
Drawing Title:
MAIN SPAN END LINK LOAD CASES (SHEET 4 OF 4)

FAIRHURST
225 Bath Street,
GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

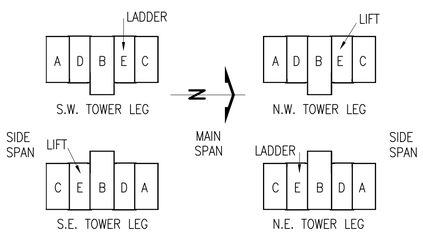
Scale at A1:	Status:	
AS SHOWN	FOR APPROVAL	
Drawn:	Checked:	Approved:
CMcL	DAJE	CAC
Date:	Date:	Date:
23/10/15	23/10/15	23/10/15

Drawing No.: 109178/1004 Revision: –

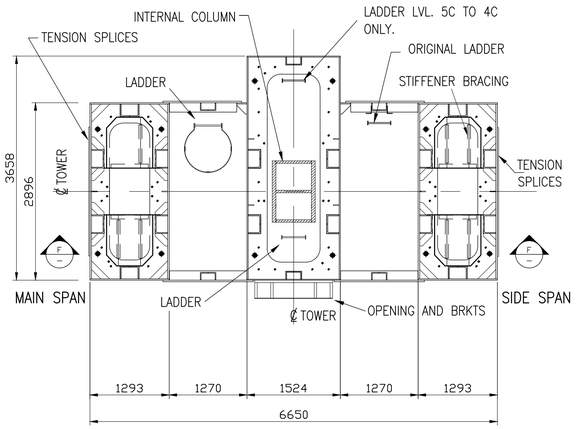
Do not scale from this drawing.



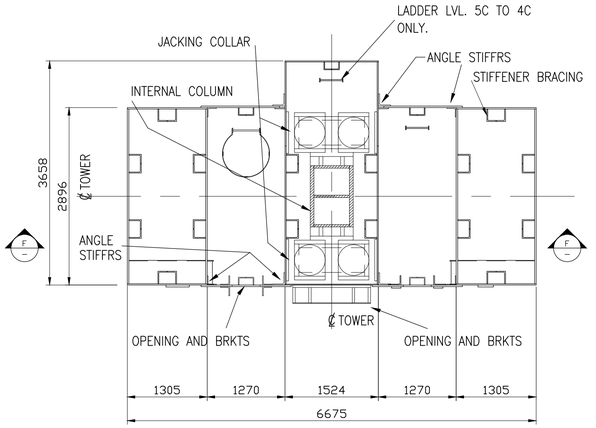
SECTION F–F 1:50
(N.E. TOWER LEG)



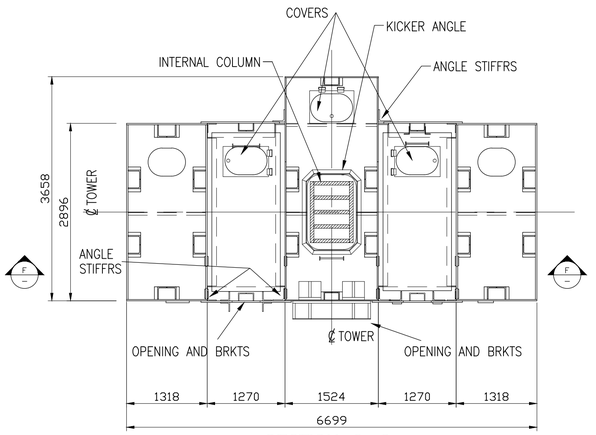
KEY PLAN
SHOWING CELL REF's, LOCATION OF LIFT SHAFTS & LADDERS



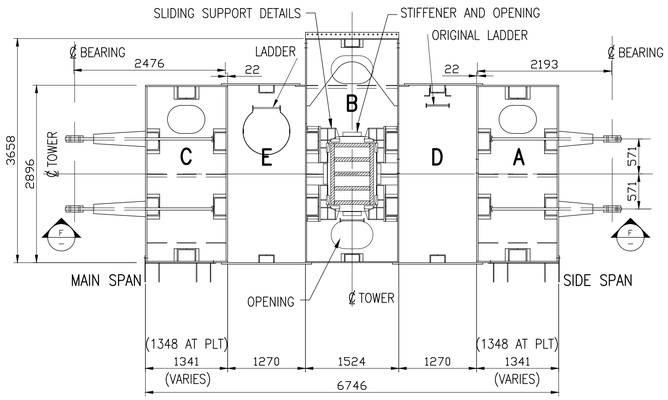
SECTION A–A 1:50



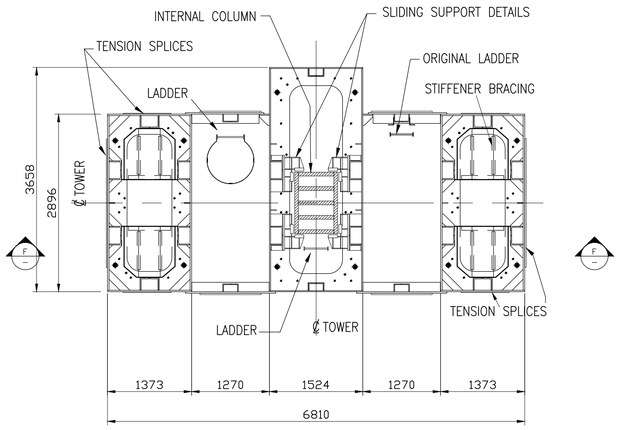
SECTION B–B



SECTION C–C



SECTION D–D



SECTION E–E

Rev.	Date	Description	Drawn	Checked	Approved

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES U.N.O
2. ALL LEVELS ARE IN METRES AND RELATED TO OS DATUM.
3. DO NOT SCALE. USE NOTED DIMENSION ONLY.
4. THE INFORMATION SHOWN ON THIS DRAWING IS BASED ON RECORD DRAWINGS OF THE EXISTING FORTH ROAD BRIDGE LISTED IN THE APPROVAL IN PRINCIPLE. THE CONTRACTOR SHALL NOTE THAT THE RECORD DRAWINGS FROM THE ORIGINAL CONSTRUCTION ARE NOT AS BUILT.
5. THE DIMENSIONS OF THE EXISTING STRUCTURE WHICH AFFECT THE PROPOSED WORKS ARE TO BE CONFIRMED BY THE CONTRACTOR ON SITE PRIOR TO COMMENCING FABRICATION AND/OR CONSTRUCTION AND ANY DISCREPANCIES TO BE ADVISED TO FAIRHURST.
6. DRAWING TO BE READ IN CONJUNCTION WITH DRAWING NO.
   109178A/012 – GENERAL ARRANGEMENT OF EXISTING MAIN TOWER LEGS FOURTH PORTION (SHEET 2 OF 2)
   109178A/013 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 1 OF 2)
   109178A/014 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 2 OF 2)
   109178A/015 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 1 OF 3)
   109178A/016 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 2 OF 3)
   109178A/017 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 3 OF 3)
7. FOR RESIDUAL HAZARDS ASSOCIATED WITH THE STRENGTHENING WORKS, REFER TO DRGs. 109178A/013 & 014 .

Client: amey / TRANSPORT SCOTLAND

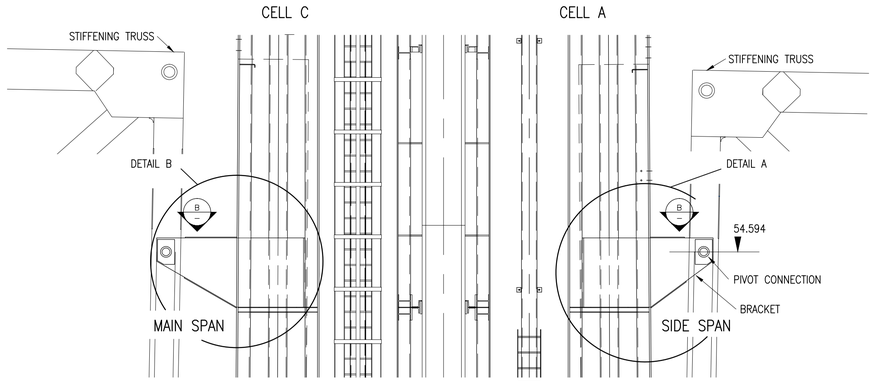
Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title:
GENERAL ARRANGEMENT OF EXISTING MAIN TOWER LEGS FOURTH PORTION (SHEET 1 OF 2)

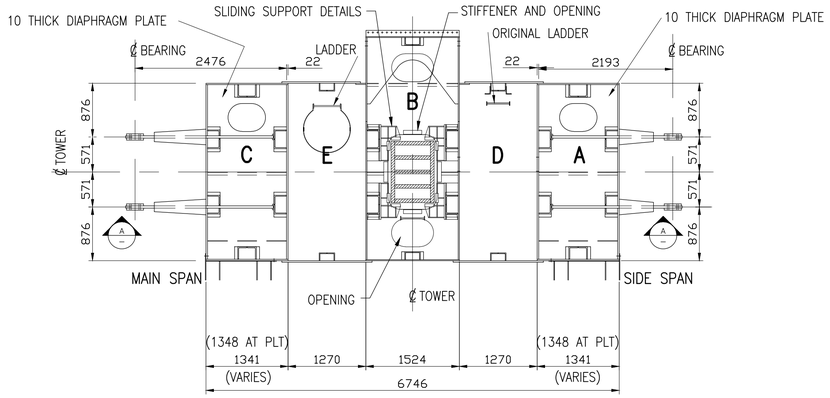
FAIRHURST
225 Both Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn:	Checked:	Approved:
IFB	DE	CAC
Date:	Date:	Date:
28/08/15	28/08/15	28/08/15
Drawing No.:		Revision:
109178A/011		–

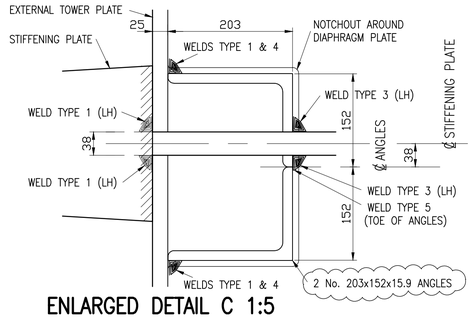
Do not scale from this drawing.



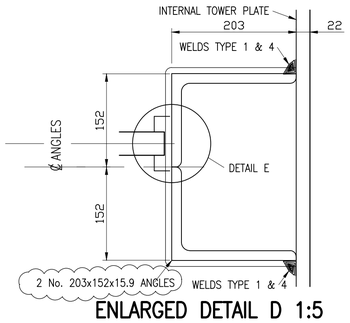
SECTION A–A 1:50



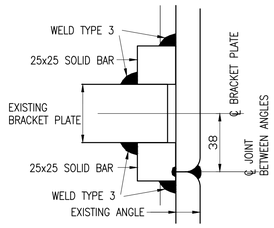
SECTION B–B
(N.E. TOWER LEG)



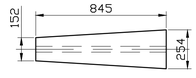
ENLARGED DETAIL C 1:5



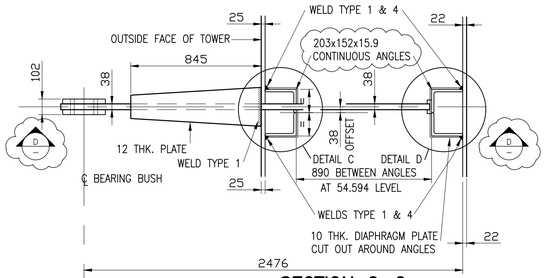
ENLARGED DETAIL D 1:5



ENLARGED DETAIL E 1:2



TOP STIFFENING PLATE
MAIN SPAN

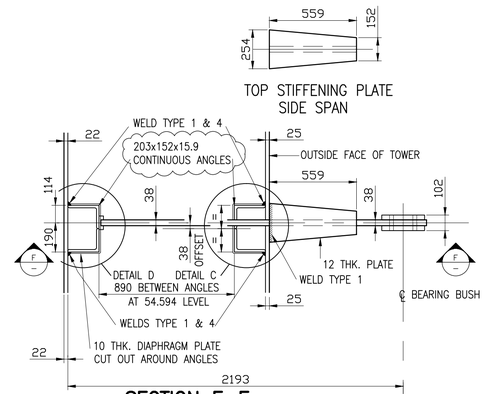


SECTION C–C

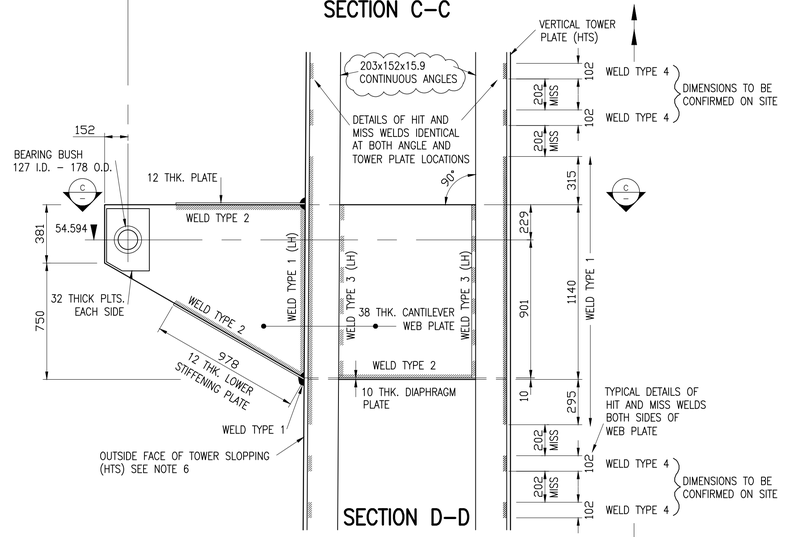
WELD TYPES & LEG LENGTHS

WELD TYPE 1 – 8/11mm. FILLET WELD ALL ROUND.
WELD TYPE 2 – 8mm. FILLET WELD.
WELD TYPE 3 – 8/11mm. 102mm. HIT, 102mm. MISS (612mm. NET LENGTH OF WELDS, 1130mm OVERALL LENGTH). INSPECTION BY F.R.B. HAS FOUND THAT ON THE SOUTH EAST AND SOUTH WEST TOWER LEGS WELD TYPE 3 HAS BEEN INSTALLED AS CONTINUOUS. THE DIMENSIONS ARE TO BE CONFIRMED BY THE CONTRACTOR. DETAILS SHOWN HERE REFLECT THE INFORMATION ON THE RECORD DRAWINGS.
WELD TYPE 4 – 8/11mm. 102mm. HIT, 203mm MISS OVER REMAINING LENGTH OF ANGLES.
WELD TYPE 5 – 6mm. 102mm. HIT, 203mm MISS.

ORIENTATION OF WELD LEGS TO BE CONFIRMED ON SITE.

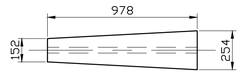


SECTION E–E

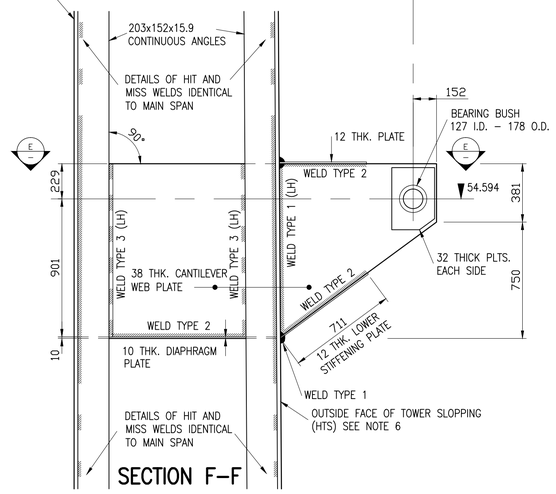


SECTION D–D

ENLARGED DETAIL B 1:20
MAIN SPAN

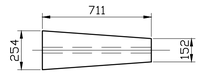


LOWER STIFFENING PLATE
MAIN SPAN



SECTION F–F

ENLARGED DETAIL A 1:20
SIDE SPAN



LOWER STIFFENING PLATE
SIDE SPAN

Rev.	Date	Description	Drawn	Checked	Approved
A	19/10/15	AMMENDMENTS SHOWN CLOUDED	CMcL	DAJE	CAC

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES U.N.O
2. ALL LEVELS ARE IN METRES AND RELATED TO OS DATUM.
3. DO NOT SCALE. USE NOTED DIMENSION ONLY.
4. THE INFORMATION SHOWN ON THIS DRAWING IS BASED ON RECORD DRAWINGS OF THE EXISTING FORTH ROAD BRIDGE LISTED IN THE APPROVAL IN PRINCIPLE. THE CONTRACTOR SHALL NOTE THAT THE RECORD DRAWINGS FROM THE ORIGINAL CONSTRUCTION ARE NOT AS BUILT.
5. THE DIMENSIONS OF THE EXISTING STRUCTURE WHICH AFFECT THE PROPOSED WORKS ARE TO BE CONFIRMED BY THE CONTRACTOR ON SITE PRIOR TO COMMENCING FABRICATION AND/OR CONSTRUCTION AND ANY DISCREPANCIES TO BE ADVISED TO FAIRHURST.
6. EXISTING STEEL SECTIONS AND PLATES FOR THE ORIGINAL TOWER CONSTRUCTION ARE TO THE FOLLOWING SPECIFICATION.
   - MAIN PLATES FORMING THE TOWER LEGS INCLUDING CELL COVER PLATES (MARKED HTS) ARE HIGH TENSILE STEEL TO BS 968: 1943 TYPE A
   - ALL OTHER ORIGINAL TOWER EXISTING STEEL PLATES AND SECTIONS INCLUDING LINK BRACKETS ARE MILD STEEL TO BS 15:1948.
7. RECORD DRAWINGS INDICATE THAT ALL EXISTING WELDS WERE TO BE MADE USING 'RUTILE ELECTRODES' WITH EXCEPTION TO WELDS MARKED THUS (LH) WHERE LOW HYDROGEN ELECTRODES WERE TO BE USED.
8. DRAWING TO BE READ IN CONJUNCTION WITH DRAWING NO.
   109178A/011 – GENERAL ARRANGEMENT OF EXISTING MAIN TOWER LEGS FOURTH PORTION (SHEET 1 OF 2)
   109178A/013 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 1 OF 2)
   109178A/014 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 2 OF 2)
   109178A/015 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 1 OF 3)
   109178A/016 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 2 OF 3)
   109178A/017 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 3 OF 3)
9. FOR RESIDUAL HAZARDS ASSOCIATED WITH THE STRENGTHENING WORKS, REFER TO DRGS.109178A/013 & 014.

Client: amey / TRANSPORT SCOTLAND

Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

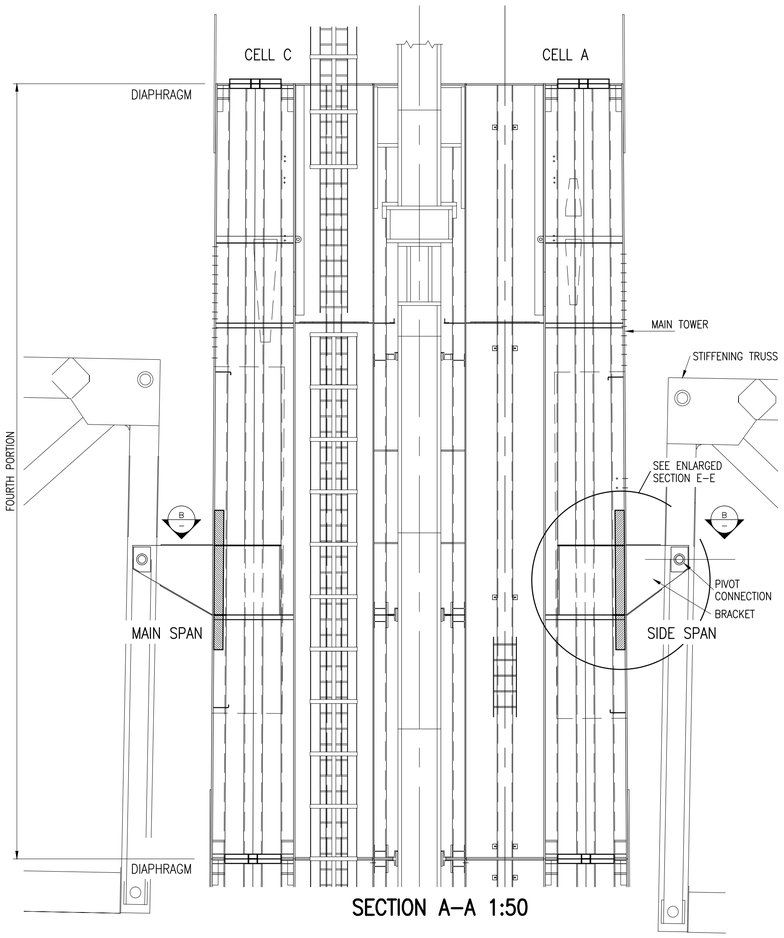
Drawing Title:
GENERAL ARRANGEMENT OF EXISTING MAIN TOWERS LEGS FOURTH PORTION (SHEET 2 OF 2)

FAIRHURST
225 Bath Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

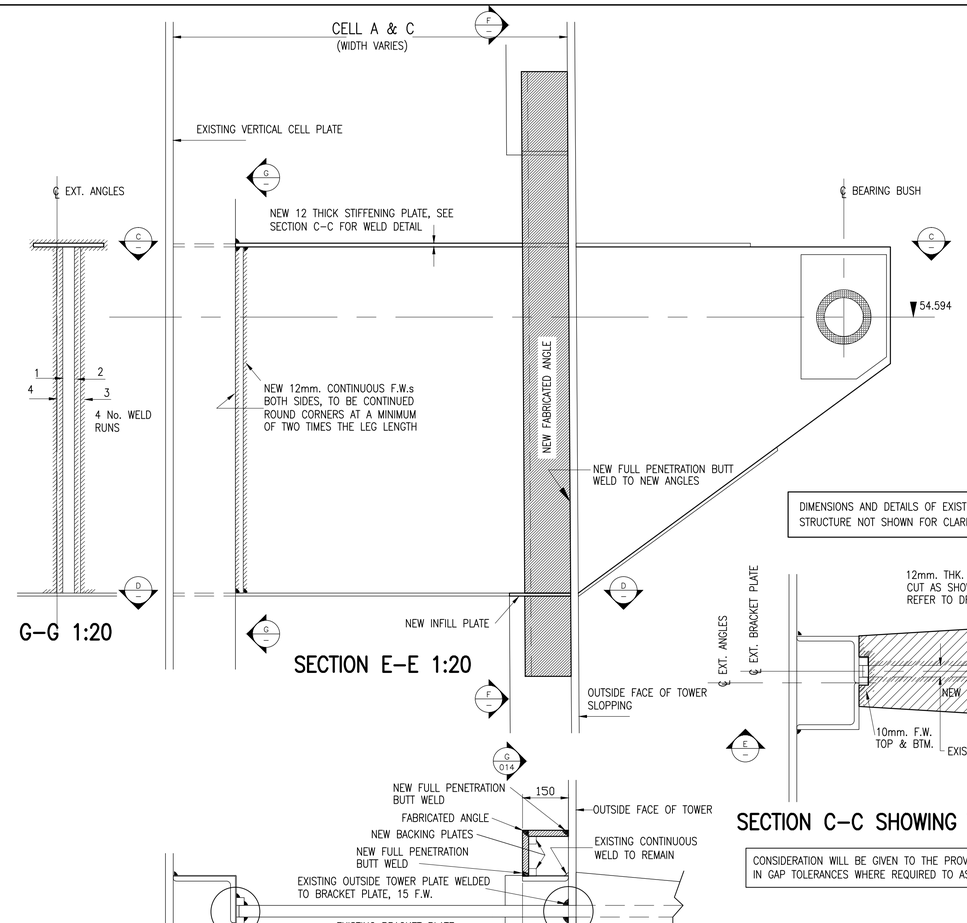
Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn:	Checked:	Approved:
IFB	DE	CAC
Date:	Date:	Date:
28/08/15	28/08/15	28/08/15

Drawing No.: 109178A/012 Revision: A

Do not scale from this drawing.



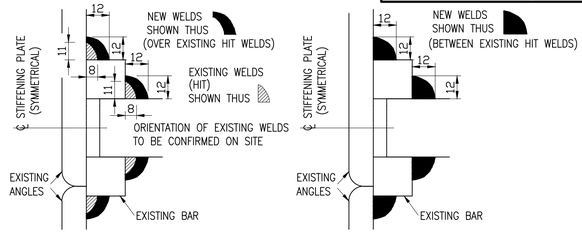
SECTION A–A 1:50



G–G 1:20

SECTION E–E 1:20

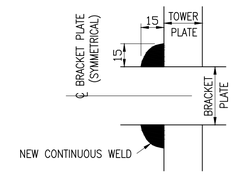
DIMENSIONS AND DETAILS OF EXISTING STRUCTURE NOT SHOWN FOR CLARITY



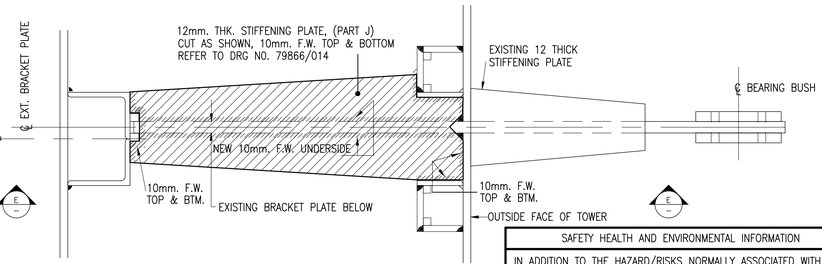
NEW WELDS OVER EXISTING HIT WELDS

NEW WELDS BETWEEN EXISTING WELDS

ENLARGED DETAIL A 1:2



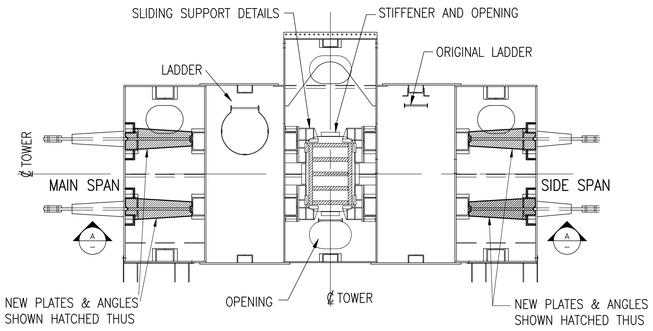
ENLARGED DETAIL B 1:2



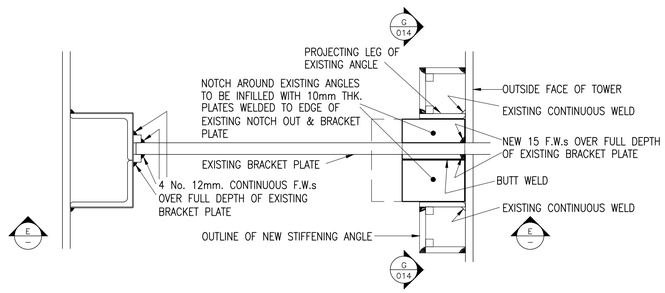
SECTION C–C SHOWING TOP STIFFENING PLATE 1:10

CONSIDERATION WILL BE GIVEN TO THE PROVISION OF COPE HOLES AND UP TO 1mm INCREASE IN GAP TOLERANCES WHERE REQUIRED TO ASSIST FIT UP AND WELDING TO EXISTING STEELWORK.

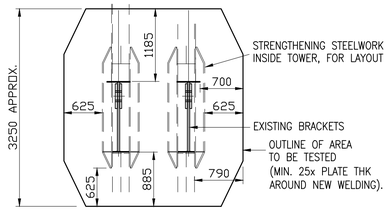
SECTION C–C SHOWING STIFFENING ANGLES 1:10



SECTION B–B
(N.E. TOWER LEG)



SECTION D–D SHOWING BOTTOM INFILL PLATES 1:10



SECTION F–F 1:50

EXTENT OF EXISTING MAIN TOWER PLATE TO BE INVESTIGATED BY ULTRA SONIC TECHNIQUES

TESTING OF EXISTING STEELWORK TO BE UNDERTAKEN IN ACCORDANCE WITH CL.3.1.4.1 OF BS5400 PART 6. ACCEPTANCE CRITERIA TARGET OF LEVEL B4 TO BS 5996.
RESULTS OF TESTING INCLUDING REPAIR PROPOSALS WHERE REQUIRED TO BE SUBMITTED TO FAIRHURST FOR COMMENT PRIOR TO UNDERTAKING SITE WELDING.

SAFETY HEALTH AND ENVIRONMENTAL INFORMATION

IN ADDITION TO THE HAZARD/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING RISKS AND INFORMATION.

RISKS LISTED HERE ARE NOT EXHAUSTIVE. REFER TO DESIGN ASSESSMENT FORM NO.

CONSTRUCTION & DEMOLITION

HAZARDOUS MATERIALS– THE EXISTING PROTECTIVE COATINGS INSIDE THE TOWER LEGS COMPRISE TWO COATS OF RED LEAD PAINT OVERCOATED WITH ACRYLATED RUBBER.

WELDING OLD STEEL – THE MAIN TOWER COMPRISES BOTH MILD AND HIGH YIELD STEEL. THE HIGH YIELD STEEL WAS MANUFACTURED TO BS 968:1943 AND IS KNOWN TO CONTAIN INCLUSIONS WHICH INCREASE THE RISK OF LAMINAR DEFECTS BEING CREATED BY WELDING. TESTING OF ALL PLATES AFFECTED BY WELDING IS REQUIRED IN ADVANCE OF UNDERTAKING THE WORKS AS REQUIRED BY THE DRAWINGS.

CONFINED SPACE – (TOWER INTERIOR) THE FORTH ROAD BRIDGE DESIGNATE THE MAIN TOWER AS A CONFINED SPACE. VENTILATION OF THE WORKING AREAS WILL REQUIRE CONSIDERATION GIVEN THE NATURE OF WORKS BEING UNDERTAKEN.

CONFINED SPACE – (TOWER EXTERIOR) ACCESS BETWEEN THE LINK BRACKETS OUTSIDE THE TOWER IS LIMITED BY THE POSITION OF THE MAIN TRUSS. THE CONTRACTOR SHALL NOTE THAT THE MAIN TRUSS IS DESIGNED TO MOVE AND THE SPACE BETWEEN TOWER AND TRUSS VARIES DEPENDING ON THE TRAFFIC AND WIND LOAD ON THE BRIDGE.

ACCESS – ACCESS ROUTES TO THE WORK FRONTS VARY BETWEEN LOCATIONS DUE TO LOCATION OF OPENINGS AND THE PRESENCE OF THE LIFT IN TWO OF THE FOUR TOWERS. ACCESS IS ALSO RESTRICTED BY THE SIZE AND LOCATION OF OPENINGS IN THE MAIN TOWER AND DIAPHRAGM PLATES

DESIGN LOAD – THE MAXIMUM LIVE LOADING IS BASED ON THE 2010 BRIDGE SPECIFIC ASSESSMENT LIVE LOADING (BSALL) WITH A 1IN10 YEAR RETURN PERIOD AS DETAILED IN THE ADDENDUM REPORT BY W.A. FAIRHURST AND PARTNERS DATED 9th FEBRUARY 2010 AND SOV AS SET OUT IN FAIRHURST REPORT DATED MARCH 2014. THE MAXIMUM LOAD CONSIDERED PER END LINK WAS A TENSILE FORCE OF 1.61MN FROM A COMBINATION OF 170 TONNE SOV AND BSALL. A MAXIMUM SINGLE SOV OF 250 TONNES WAS CONSIDERED TO PRODUCE A LOAD OF 1.47MN.

FOR INFORMATION RELATING TO USE, CLEANING AND MAINTENANCE SEE THE HEALTH AND SAFETY FILE

IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROVED METHOD STATEMENT.

Rev.	Date	Description	Drawn	Checked	Approved
A	18/09/15	NOTES AMENDED	CK	DAJE	CAC

NOTES
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7. WORKS TO BE CARRIED OUT IN ACCORDANCE WITH THE SPECIFICATION.

Client: amey / TRANSPORT SCOTLAND

Project Title: FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

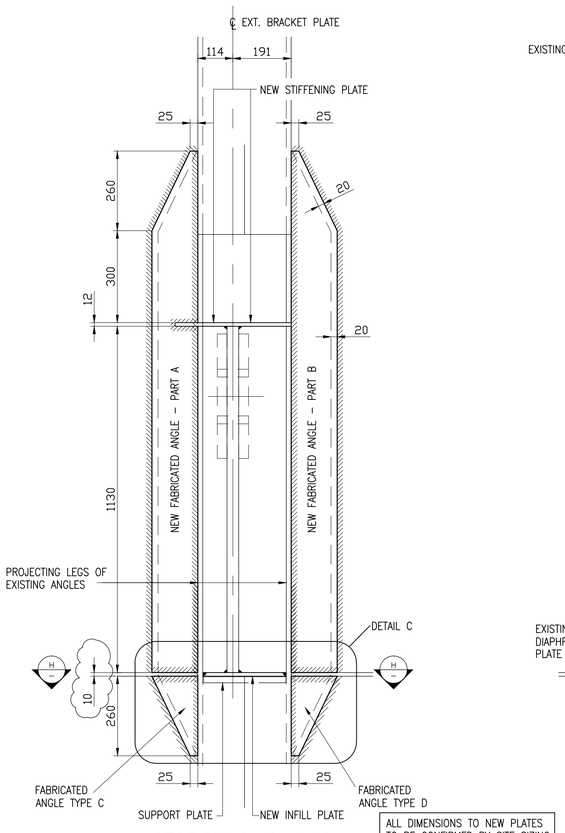
Drawing Title: PROPOSED STRENGTHENING WORKS ASSEMBLED SHEET 1 OF 2

FAIRHURST
225 Bath Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn: IFB	Checked: DE	Approved: CAC
Date: 28/08/15	Date: 28/08/15	Date: 28/08/15

Drawing No.: 109178A/013 Revision: –

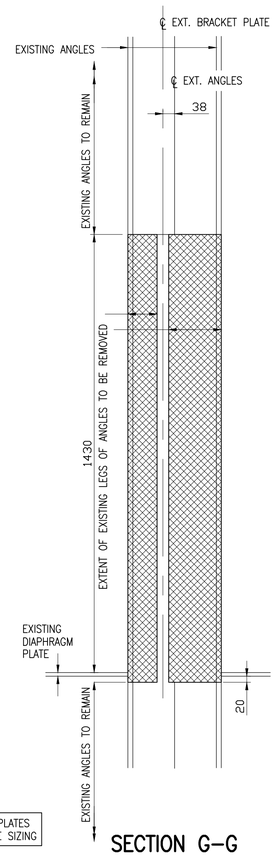
Do not scale from this drawing.



ALL DIMENSIONS TO NEW PLATES TO BE CONFIRMED BY SITE SIZING

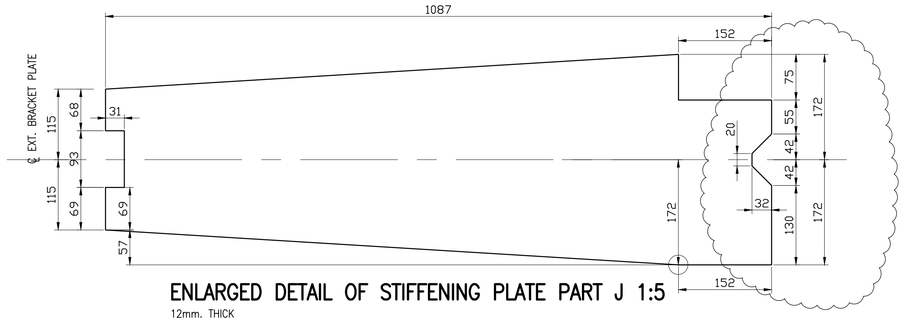
SECTION G–G 1:10

SHOWING NEW FABRICATED ANGLES
(FOR LOCATION OF SECTION G–G REFER TO DRG. 013)



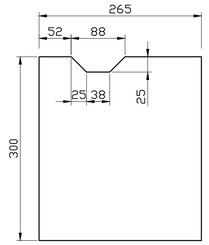
SECTION G–G

SHOWING EXTENT OF EXISTING
ANGLES TO BE REMOVED

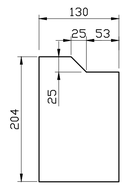


ENLARGED DETAIL OF STIFFENING PLATE PART J 1:5

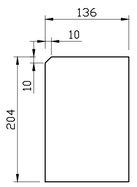
12mm. THICK



SUPPORT PLATE PART K
10mm. THICK

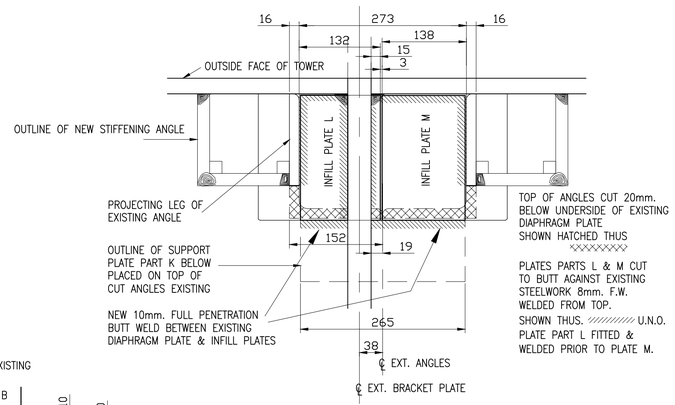


INFILL PLATE PART L
10mm. THICK

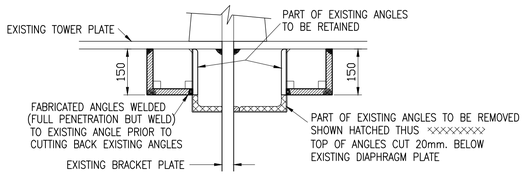


INFILL PLATE PART M
10mm. THICK

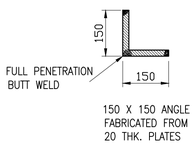
ALL DIMENSIONS TO NEW PLATES TO BE CONFIRMED BY SITE SIZING



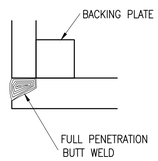
ENLARGED DETAILS OF INFILL PLATES 1:5



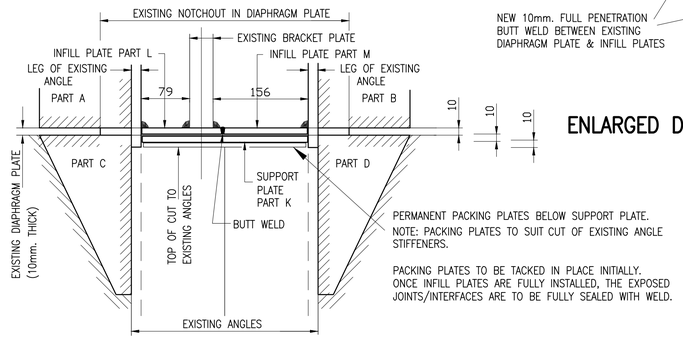
SECTION H–H



150 X 150 ANGLE
FABRICATED FROM
20 THK. PLATES



TYPICAL BUTT WELD DETAIL 1:2



PERMANENT PACKING PLATES BELOW SUPPORT PLATE.
NOTE: PACKING PLATES TO SUIT CUT OF EXISTING ANGLE STIFFENERS.

PACKING PLATES TO BE TACKED IN PLACE INITIALLY.
ONCE INFILL PLATES ARE FULLY INSTALLED, THE EXPOSED JOINTS/INTERFACES ARE TO BE FULLY SEALED WITH WELD.

ENLARGED DETAIL C 1:5

SAFETY HEALTH AND ENVIRONMENTAL INFORMATION

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Rev.	Date	Description	Drawn	Checked	Approved
B	19/10/15	AMMENDMENTS SHOWN CLOUDED	CMcL	DAJE	CAC
A	18/09/15	REMOVAL OF PROTECTIVE COATING NOTE.	CMcL	DAJE	CAC

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7. WORKS TO BE CARRIED OUT IN ACCORDANCE WITH THE SPECIFICATION.

Client: amey / TRANSPORT SCOTLAND

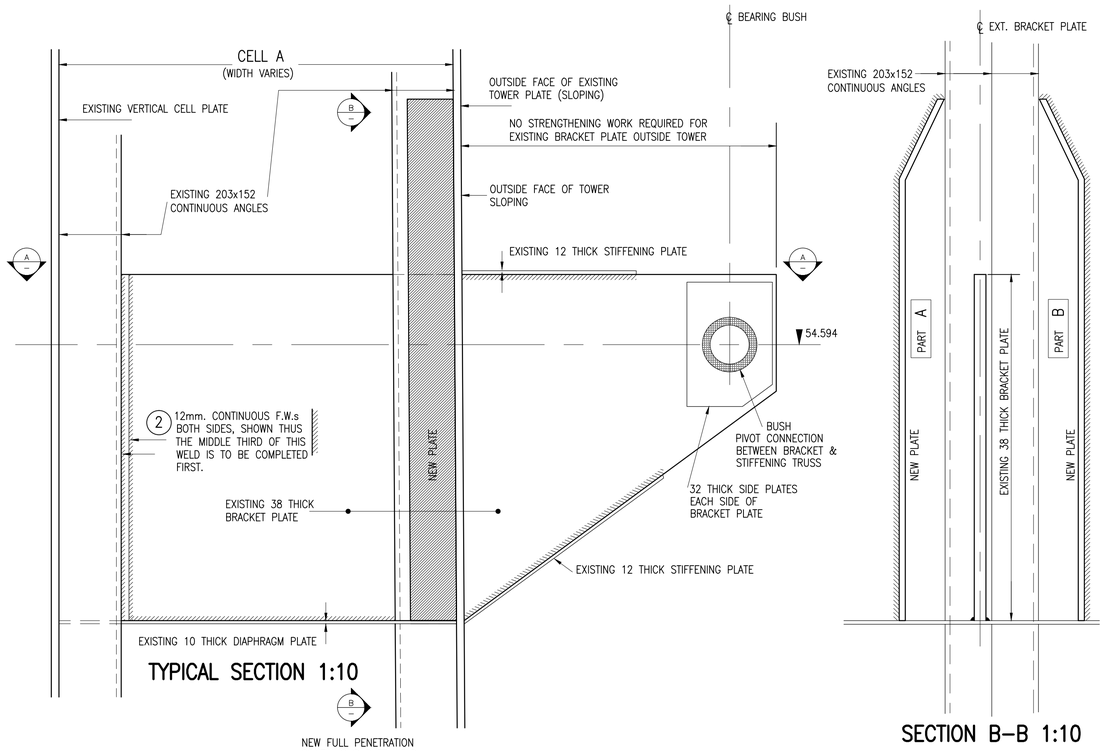
Project Title:
FORTH ROAD BRIDGE
STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title:
PROPOSED STRENGTHENING WORKS ASSEMBLED
SHEET 2 OF 2

FAIRHURST
225 Bath Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

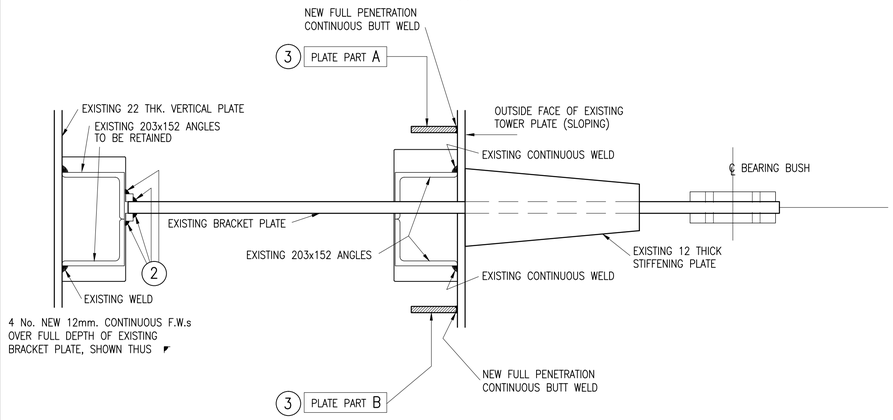
Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn: IFB	Checked: DE	Approved: CAC
Date: 28/08/15	Date: 28/08/15	Date: 28/08/15
Drawing No.: 109178A/014		Revision: B

Do not scale from this drawing.



SECTION B–B 1:10

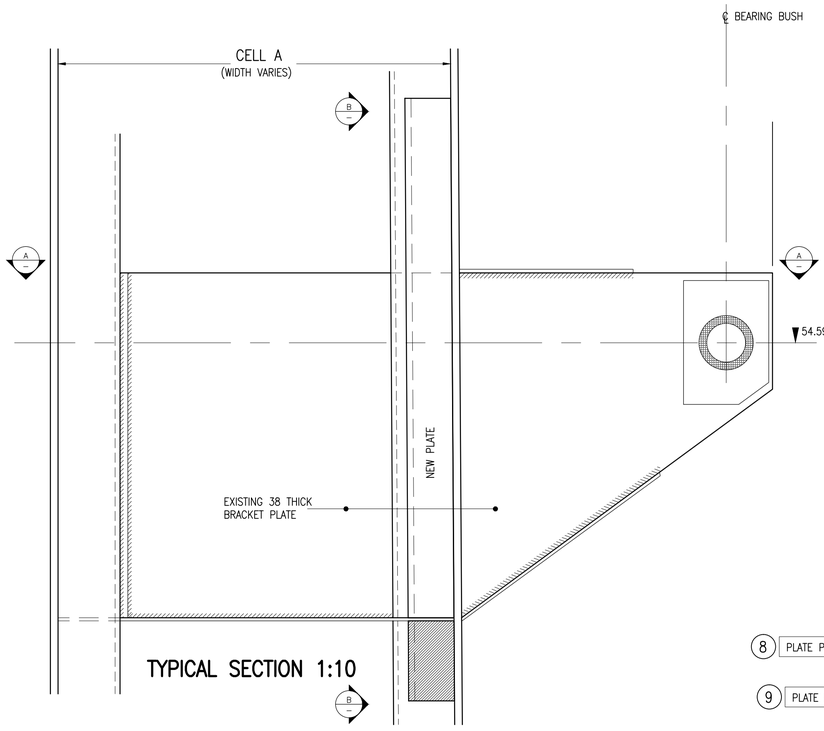
SHOWING NEW PLATES
FULL PENETRATION
BUTT WELDS SHOWN THUS

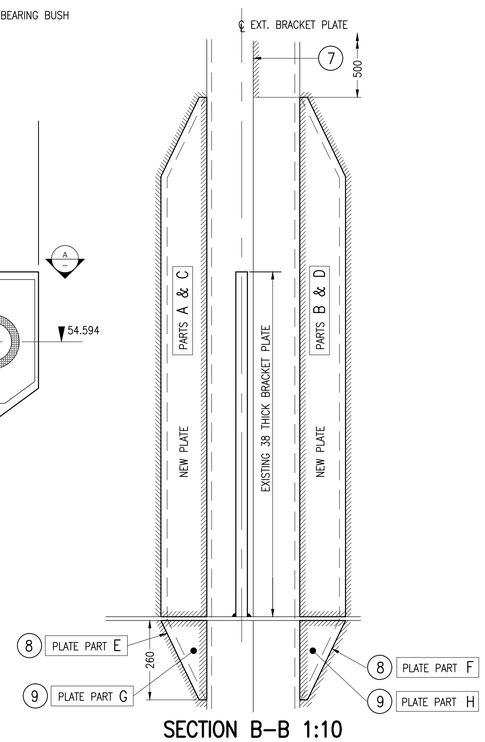


SECTION A–A 1:10

CONSTRUCTION STAGES

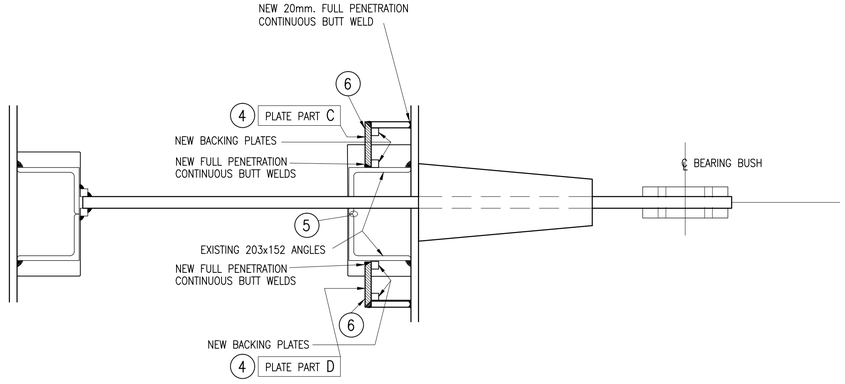
1. ALL EXISTING PLATES TO BE WELDED ARE TO BE TESTED USING ULTRASONIC PRIOR TO WELDING. REFER TO DRAWING NO. 79866/13. RESULTS OF TESTING INCLUDING PROPOSALS TO REPAIR AND DEFECTS TO BE PROVIDED TO FAIRHURST FOR COMMENT PRIOR TO UNDERTAKING ANY SITE WELDING.
2. INSTALL 4No. 12mm. CONTINUOUS F.W.s TO EXISTING ANGLES AND BRACKET PLATE OVER FULL 1130 DEPTH OF EXISTING BRACKET PLATE.
3. INSTALL PLATE PARTS A, & B. AS SHOWN.





SECTION B–B 1:10

SHOWING NEW PLATES
FULL PENETRATION
BUTT WELDS SHOWN THUS



SECTION A–A 1:10

CONSTRUCTION STAGES

4. INSTALL PLATE PARTS C, & D. TO EXISTING 203x152 ANGLES FIRST WITH FULL PENETRATION BUTT WELD.
5. CUT WELD BETWEEN EXISTING ANGLES FROM DIAPHRAGM PLATE TO 500mm ABOVE TOP OF FABRICATED ANGLE SECTIONS.
6. WELD PLATES A, to C. AND B, to D. USING PENETRATION CONTINUOUS BUTT WELDS.
7. REINSTATE WELD SECTION ABOVE NEW PLATES ONLY.
8. INSTALL PLATES, E, & F. ANGLED BETWEEN UNDERSIDE OF DIAPHRAGM & EXISTING ANGLES WITH FULL PENETRATION BUTT WELD.
9. INSTALL PLATES, G, & H. (TRIANGLULAR SHAPED) TO EXISTING 203x152 ANGLES FIRST WITH FULL PENETRATION BUTT WELD.
10. CUT WELD BETWEEN EXISTING ANGLE FROM BOTTOM OF DIAPHRAGM TO 200mm PAST EXTENT OF PARTS E AND F.
11. WELD PLATES E, to G. AND F, to H WITH FULL PENETRATION BUTT WELD.
12. REINSTATE WELD BETWEEN EXISTING ANGLE BELOW DIAPHRAGM.

Rev.	Date	Description	Drawn	Checked	Approved

NOTES
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2. ALL LEVELS ARE IN METRES AND RELATED TO OS DATUM.
3. DO NOT SCALE. USE NOTED DIMENSION ONLY.
4. DRAWING TO BE READ IN CONJUNCTION WITH DRAWING NO.
   - 109178A/011 – GENERAL ARRANGEMENT OF EXISTING MAIN TOWER LEGS FOURTH PORTION (SHEET 1 OF 2)
   - 109178A/012 – GENERAL ARRANGEMENT OF EXISTING MAIN TOWER LEGS FOURTH PORTION (SHEET 2 OF 2)
   - 109178A/013 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 1 OF 2)
   - 109178A/014 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 2 OF 2)
   - 109178A/016 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 2 OF 3)
   - 109178A/017 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 3 OF 3)

Client: amey / TRANSPORT SCOTLAND

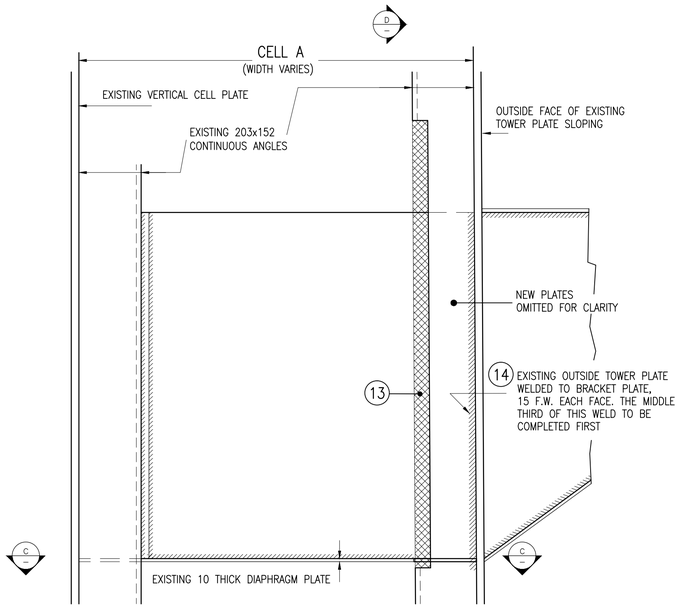
Project Title:
FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title:
PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE SHEET 1 OF 3

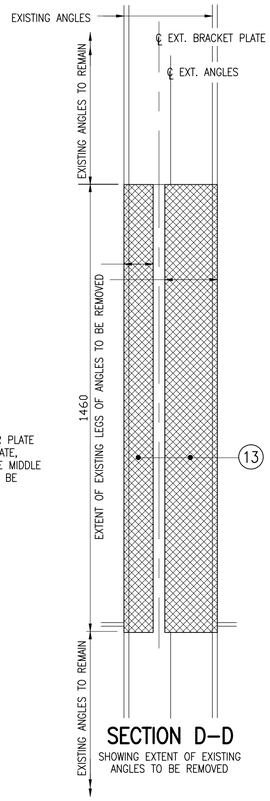
FAIRHURST
225 Bath Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn: IFB	Checked: DE	Approved: CAC
Date: 28/08/15	Date: 28/08/15	Date: 28/08/15
Drawing No.: 109178A/015		Revision: –

Do not scale from this drawing.

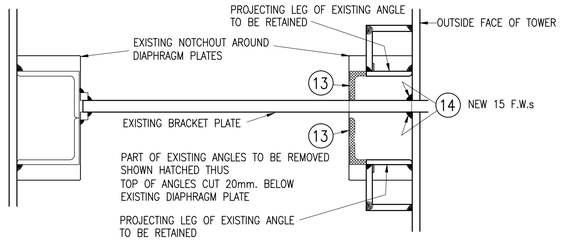


TYPICAL SECTION 1:10



SECTION D–D

SHOWING EXTENT OF EXISTING ANGLES TO BE REMOVED

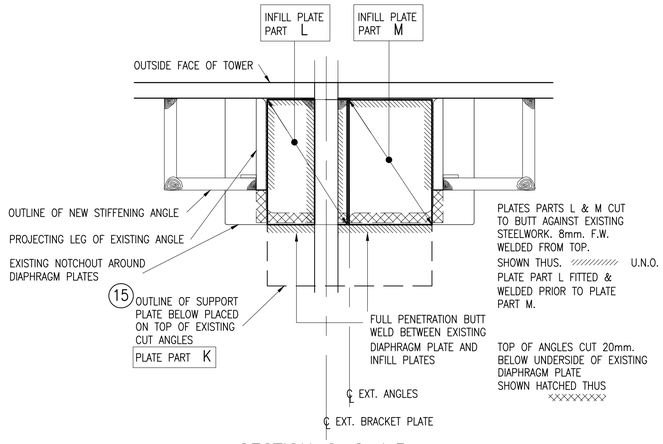


SECTION C–C 1:10

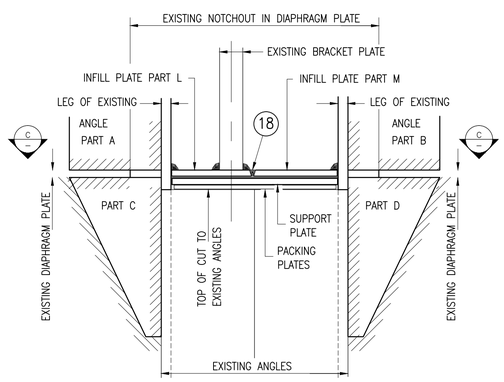
CONSTRUCTION STAGES

(13) CUT AND REMOVE PART OF EXISTING ANGLES, LEAVING 150 OF 203 LEG WELDED TO EXISTING TOWER PLATE.

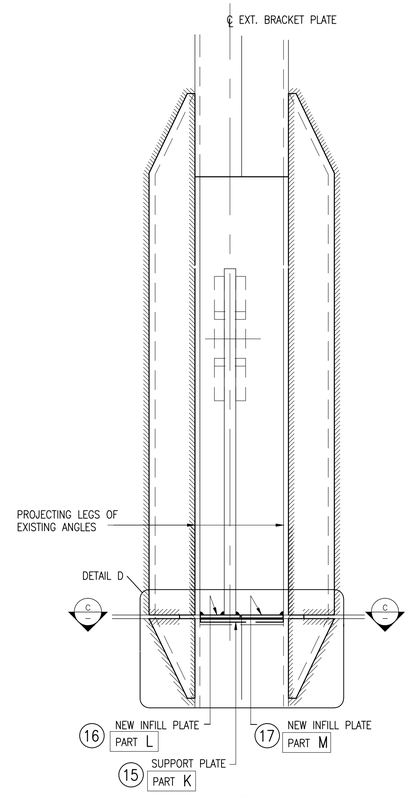
(14) INSTALL 2No. 15mm. CONTINUOUS F.W.s TO EXISTING BRACKET PLATE AND EXISTING OUTER TOWER PLATE.



SECTION C–C 1:5



ENLARGED DETAIL D 1:5



SECTION B–B 1:10

SHOWING NEW INFILL PLATES

CONSTRUCTION STAGES

(15) SUPPORT PLATE PART K INSTALLED TO SUIT LEVEL OF INFILL PLATES AS SHOWN.

(16) INFILL PLATE PART L INSTALLED BY SLIDING INTO POSITION AS SHOWN AND WELDED IN POSITION.

(17) INFILL PLATE PART M INSTALLED BY SLIDING INTO POSITION AS SHOWN AND WELDED IN POSITION.

(18) WELD PLATES L TO M WITH FULL PENETRATION BUTT WELD.

Rev.	Date	Description	Drawn	Checked	Approved

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   - 109178A/012 – GENERAL ARRANGEMENT OF EXISTING MAIN TOWER LEGS FOURTH PORTION (SHEET 2 OF 2)
   - 109178A/013 – PROPOSED STRENGTHENING WORKS ASSEMBLED (SHEET 1 OF 2)
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   - 109178A/017 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 3 OF 3)

Client: amey / TRANSPORT SCOTLAND

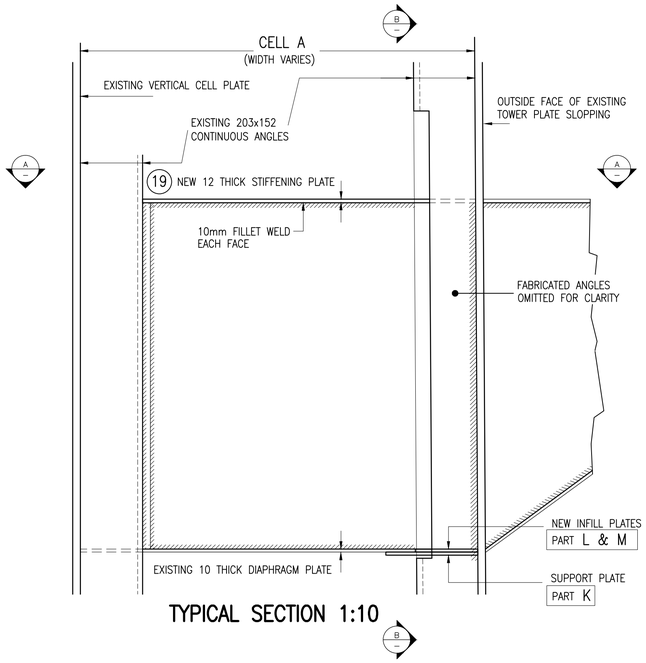
Project Title: FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title: PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE SHEET 2 OF 3

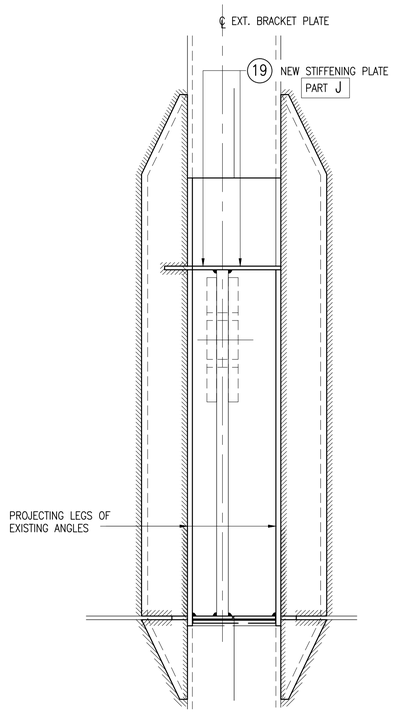
FAIRHURST
225 Bath Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn: IFB	Checked: DE	Approved: CAC
Date: 28/08/15	Date: 28/08/15	Date: 28/08/15
Drawing No.: 109178A/016		Revision: –

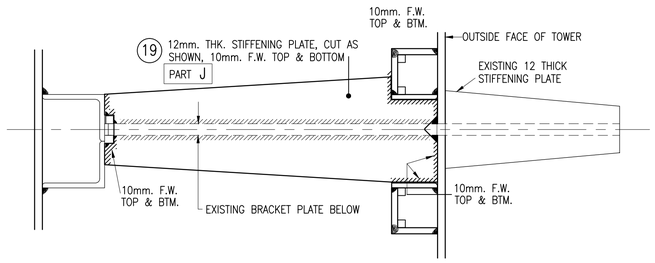
Do not scale from this drawing.



TYPICAL SECTION 1:10



SECTION B–B 1:10
SHOWING NEW STIFFENING PLATE



SECTION A–A 1:10

CONSTRUCTION STAGE

19 INSTALL NEW 12mm. THK. STIFFENING PLATE PART J AS SHOWN.

Rev.	Date	Description	Drawn	Checked	Approved

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   - 109178A/016 – PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE (SHEET 2 OF 3)

Client: amey / TRANSPORT SCOTLAND

Project Title: FORTH ROAD BRIDGE STRENGTHENING OF END LINK BRACKETS FOR N.E. & S.E. TOWERS

Drawing Title: PROPOSED STRENGTHENING WORKS CONSTRUCTION SEQUENCE SHEET 3 OF 3

FAIRHURST
225 Both Street, GLASGOW, G2 4GZ
Tel: 0141 204 8800 Fax: 0141 204 8801

Scale at A1:	Status:	
AS SHOWN	APPROVAL	
Drawn:	Checked:	Approved:
IFB	DE	CAC
Date:	Date:	Date:
28/08/15	28/08/15	28/08/15
Drawing No.: 109178A/017		Revision: –

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

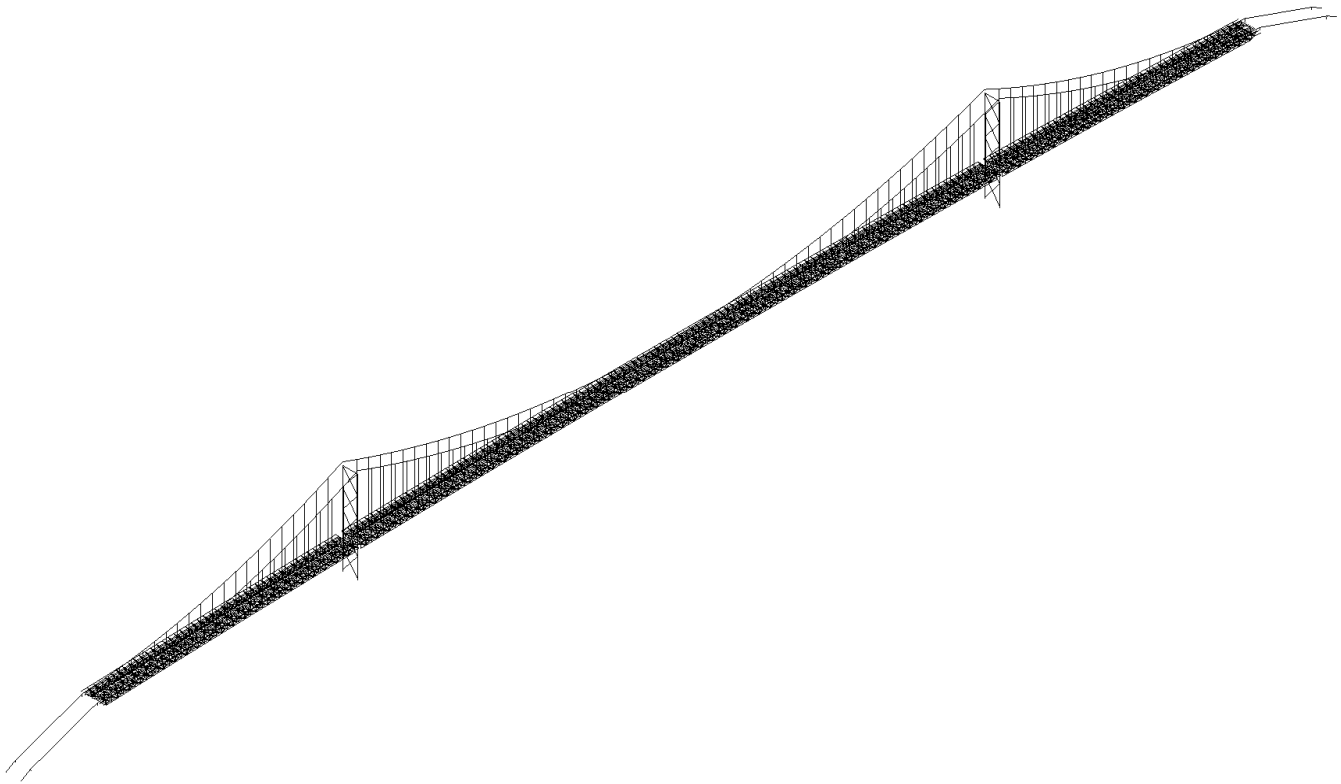

Figure 1 – Bridge model