Forth Estuary Transport Authority

Forth Road Bridge
Roller Shutter Joint – Failsafe Measures

Design Approval in Principle
Revision B

Final

June 2009

Notice

Document History

JOB NUMBER: 5057541			DOCUMENT REF: 5057541/012			
Revision	Purpose and Description	Originated	Checked	Reviewed	Authorised	Date
A	Draft					April 09
B	Final					June 09

Name of Project:	Forth Estuary Transport Authority Forth Road Bridge
Name of Bridge or Structure:	Roller Shutter Joint Failsafe Measures
Structure No:	N/A

1. HIGHWAYS DETAILS

1.1. Type of Highway

Over: 2 lane dual carriageway.

1.2. Permitted Traffic Speed

Over: 50 mph

1.3. Existing Weight Restriction

None

2. SITE DETAILS

2.1. Obstacles Crossed

2 No roller shutter movement joints exist at each main suspension tower in each carriageway; they span the gaps between the towers and both the main and side spans.

3. EXISTING AND PROPOSED STRUCTURE

3.1. Existing Roller Shutter Movement Joints

3.1.1 Description

The existing roller shutter movement joints were manufactured by Demag and were commissioned in 1964. The joints are located adjacent to the main suspension towers and are of two different lengths. The joints between the towers and the central span are approximately 5.0metres long with a specified +810/-920mm movement range, whilst the joints between the towers and the side spans are approximately 2.5metres long with a specified +150/-260mm movement range.

In total there are 8 No sets of joint units, 4 No sets in each carriageway. Each set comprises 6 No units of varying width, the 4 No inner units are 1228mm wide, the edge units adjacent to the central reserve are 1245mm wide and the edge units adjacent to the verge are 1340mm wide.

Each unit has a tongue plate and movement train. The latter comprises a shuttle (bridge) plate and a number of link (train) plates, 5 No link plates in the longer units and 2 No in the shorter units. The trains are supported on curved beam slide tracks. With the exception of the outer slide track, each beam supports one side of adjacent pairs of trains.

The tongue plates and slide tracks of both the large and small joints are bolted to steelwork grillages that are connected to the main towers. Each tongue plate is attached to the support beam by a pair of spring loaded holding down bolts.

The shuttle and link plates of the trains are supported at four corners by bearing cams and/or steel bearing blocks. Further blocks are welded to the underside of the plates in the region of the slide tracks to restrain the trains from moving laterally.

The shuttle plates of the trains are connected to the main and side spans, and movement of these deck spans is accommodated by the trains moving along the slide tracks and under the tongue plates Provision is made at the ends of the shuttle plates for the plan rotation of the deck ends when the spans are

subject to lateral loading. The arrangement includes central locating blocks which maintain a clearance at the ends of the plates; and a single, central spring loaded holding down bolt capable of accommodating rotation. Rotation of the deck ends therefore gives rise to joint movement whist the longitudinal alignment of the trains is maintained.

3.1.2 Condition

Records would indicate that the joints have generally performed well, although they have now been in service for over 40 years and they last underwent a detailed inspection and overhaul in 1975. This inspection found evidence of wear in the hinges and the interface between the trains and slide tracks.

A recent sample inspection, which involved the removal of the tongue plate and train of one of the units, revealed the following defects:

- Excessive play in the connection between the plates of the train due to wear within the hinges particularly elongation of the holes;
- General wear of the shuttle and link plate bearings (cams and blocks);
- Wear of the slide track with localised surface indentations;
- Excessive wear of the steel pads that interface with the bearing blocks at the end of the shuttle plates.

3.2 Proposed Failsafe Measures

Proposals to replace the roller shutter joints have been put on hold pending the construction of the Forth Replacement Crossing in 2016. Delaying the replacement of the joints offers cost savings in terms of temporary bridging and also reduces potential traffic disruption, and risk to the travelling public, as there will be a suitable alternative diversion route.

However, as described in 3.1.2 above, the joints are excessively worn and there is an increasing risk of failure of a component of the joints before they are replaced. As a consequence a Failure Mode and Evaluation Analysis was undertaken to identify areas of concern. Full details of this analysis are detailed in 'Forth Road Bridge – Extending the Life of the Main Expansion Joints' (Atkins document reference 5057541/011).

The analysis concluded that the life of the joints could be extended subject to certain measures being put into place. In summary, these are:

- Increased inspections;
- Improved access walkways under the bridge deck;
- Installing additional restraint at the anchored end of the shuttle plates;
- Installing longitudinal restraint straps / cables under the plate trains;
- Installing stop end blocks on the track beams to prevent the plate trains falling into the joint;
- Replacing the shuttle and tongue plate holding down pins and springs.

Should future inspections show that the joint condition is deteriorating so that failure of a joint unit may still occur before 2016 then consideration will be given to full replacement of the joint units before that date.

This AIP covers the additional restraints of the shuttle plates and plate trains, stop end blocks and pin and spring replacement. The alterations to the access walkways are the subject of a separate AIP.

3.3 Materials Assumed for the Failsafe Measures

Materials	Type / Description
Steelwork: restraining straps and bars.	Grade S355NL to BS EN 10025 Part 3
Steelwork: angle for end stop	Grade S235J2 to BS EN 10025 Part 3
Bolts and associated nuts, washers and split pins.	Bolts - Grade 8.8 to BS 3692: 2001. Nuts – Grade 8 to BS 3692: 2001. Steel washers – Hardness class 200HV to EN ISO 7089. Nylon washers – Grade 66 Split Pins – Grade A to ISO 1234.
Lindapter Clamps (for end stops).	High friction clamps, product code AF20 and associated AF high friction packings.
Galvanising	SHW Series 1900 and BS EN ISO 1461: 1999.

3.4 Proposed Arrangements for Maintenance and Inspection

3.4.1 Traffic management

The proposals will not affect the existing arrangements for traffic management.

3.4.2 Access

Additional permanent working platforms would be required to access the underside of the joints (subject to a separate AIP).

3.4.3 Maintenance and Inspection

The failsafe measures will be designed so as not to prevent plates being lifted out. However, some disconnection will be required before lifting can take place.

3.5 Risks and Hazards Considered (DRA attached in Appendix C)

- Steelwork fabrication (cutting; welding, blasting, painting, lifting, and manual handling);
- Traffic Management including access for non-motorised users;
- Working at height in a potentially aggressive environment;
- Working adjacent to live carriageways;
- Large gaps in structure once trains are removed, protective barriers/screens required;
- Movement of joint plates due to deck movements;
- Restricted working space and headroom;
- Lifting operations;
- Site works (welding; grinding, drilling, and manual handling);
- Working adjacent to existing services.

In addition to the above, the parts of the roller shutter joints considered to be at high risk have been identified in report 'Extending the Life of the Roller Shutter Joints', document reference 5057541/011.

3.6 **Estimated Cost of Proposed Structure together with other Structural Forms considered and the Reasons for their Rejection including Comparative Whole Life Costs with Date of Estimates**

Estimated cost of the failsafe measures and enhanced inspections are estimated to cost between £150,000 and £250,000. For details see 'Forth Road Bridge – Extending the Life of the Main Expansion Joints' (Atkins document reference 5057541/011).

3.7 **Proposed Arrangements for Construction**

3.7.1 **Traffic Management**

Closure of the carriageway will be required whilst the failsafe measures are installed. Inspection of the measures can be undertaken by gaining access via the walkways and will require no traffic management.

Access for non-motorised users will be maintained at all times.

3.7.2 **Service Diversions**

None.

3.7.3 **Interface with Existing Structures**

None.

4 DESIGN CRITERIA

4.1 **Live Loading, Headroom**

4.1.1 **Loading relating to normal traffic under AW regulations and C&U regulations**

For vertical loading taken by existing plate train, HB wheel loads are critical.

4.1.2 **Loading relating to General Order Traffic under STGO regulations**

45 units HB wheel loads. Number and position of wheels on plates varied to give worst loading conditions (see Section 5.1).

4.1.3 **Footway or Footbridge Live Loading**

Not Applicable.

4.1.4 **Loading relating to Special Order Traffic, provision for exceptional abnormal indivisible loads including location of vehicle track on deck cross-section**

None.

4.1.5 **Any Special Loading Not Covered Above**

It is anticipated that the failsafe measures will only be in place for the duration of the existing roller shutter joints and that full replacement of the joints will take place soon after 2016.

For the design of the plate train restraint measures, loading in accordance with section 5 of BD33/94 will be considered in lieu of accidental skidding load to BD37/01. This gives a nominal loading of 80kN per linear metre run of joint. The widest joint is 1.34 metres giving a horizontal load of 107.2kN. An analysis of the traffic load data for the year 2008 supplied by FETA indicates that only 0.4% of vehicles have an axle load greater than 10,000kg. The legal minimum standard for brake performance of standard heavy goods vehicles is a deceleration of at least 0.5g. Research by TRL suggests that deceleration levels for modern HGVs can be as much as 0.78g, and a performance of over 0.8g would be difficult to achieve because of the limitations of available

friction between tyres and road surfaces. A 10,000kg axle with a deceleration of 0.8g gives a horizontal load of 78.5kN. The horizontal loading provided in BD33/94 is therefore proposed.

For the design of the end stops loading will consider the dead load of the whole plate train only. The end stops are considered to be a secondary measure that will only prevent the loss of the plate train into the joint itself.

4.1.6 **Heavy or high load route requirements and arrangements being made to preserve the route, including any provision for future heavier loads or future widening.**

Not applicable. The bridge is not on a heavy or high load route.

4.1.7 **Minimum Headroom Provided -**

Not applicable.

4.1.8 **Authorities consulted and any Special Conditions Required**

None

4.2 **List of Relevant Documents from the TAS**

See Appendix A.

4.2.1 **Additional Relevant Standards.**

BS EN 1993-1-8:2005 Eurocode 3. Design of Steel Structures.

4.3 **Proposed Departures from Standards given in 4.2 and 4.2.1**

None

4.4 **Proposed methods for dealing with aspects not covered by Standards in 4.2 and 4.2.1**

Not applicable.

5 STRUCTURAL ANALYSIS

5.1 **Methods of Analysis Proposed**

The design of the longitudinal restraining straps under the plate trains, the restraint to the shuttle plates and the stop ends will be designed by hand calculations considering dead loads, vehicle wheel loads and horizontal loading in accordance with BD33/94. . The design of the replacement bolts and springs to the existing holding down pins and springs for the shuttle and tongue plates will be based on the existing design and confirmation of the design undertaken for the replacement joints.

5.2 **Description and Diagram of Idealised Structure to be used for Analysis**

The failsafe measures will be considered as passive and would only come into effect in the event of failure of a component. The components that are most at risk of failure or have a high consequence of failure have been identified in a separate report, 'Extending the Life of the Roller Shutter Joints', document reference 5057541/011. In summary the high risk components have been identified as the shuttle and tongue plate holding down pins and springs, the hinge joints in the plate trains and the horizontal and vertical restraint to the shuttle plates. The failsafe measures are also considered to be a back up to a rigorous inspection regime to be undertaken by FETA. The design of the measures will consider the rotation of the hinges in the plate train and the rotation of the shuttle plates. In addition consideration will be given to ease of future maintenance and inspection and ensuring the design does not prevent the lifting out of the joint plates. The design will avoid the need for site welding to install and consider ease of replacement.
The measures incorporate a number of bolted connections and the bolts will be considered as acting in both shear and bending. To allow rotation of connections the bolts will not be acting under tension.

5.3 **Assumptions intended for Calculation of Structural Element Stiffness**

Gross cross section areas of the steel will be used to calculate section properties.

5.4 **Proposed Earth Pressure Coefficients (Ka, Ko or Kp) to be used in Design of Earth Retaining Elements**

Not applicable.

6 GEOTECHNICAL CONDITIONS

6.1 **Acceptance of Recommendations of Section 8 of the Geotechnical Report to be used in the design and reasons for any proposed changes**

Not applicable.

6.2 **Geotechnical Report Structure Design Summary Sheet (Form C)**

Not applicable.

6.3 **Differential Settlement to be Allowed for in Design of the Structure**

Not applicable.

6.4 **If the Geotechnical 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**

Category 2.

7.2 **If Category 3, Name of Proposed Independent Checker**

Not applicable

7.3 **Erection Proposals or Temporary Works for which an independent check will be required, listing parts of the structure affected with reasons for recommending an independent check**

None.

8 DRAWINGS AND DOCUMENTS

8.1 **List of Drawings (Including Numbers) and Documents accompanying the Submission**

Appendix A Technical Approval Schedule (TAS)

Appendix B Drawings

Drawing Number	Drawing Title
5057341/314/100	Details of Restraint to Shuttle Plate.
5057341/314/101	Details of Restraint to Plate Train.
5057341/314/102	Details of Stop End Restraints.
5057341/314/103	Details of Replacement Holding Down Bolts to the Shuttle and Tongue Plates

Appendix C Hazard Identification and Risk Assessments

9 **THE ABOVE IS SUBMITTED FOR ACCEPTANCE**

Signed .....

Name
Design Team Leader

Engineering Qualifications

Name of Organisation Atkins Limited

Date .....

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

Signed .....

Name .....

Position held .....

Engineering Qualifications .....

TAA .....

Date .....

APPENDIX A

TECHNICAL APPROVAL SCHEDULE "TAS" (JANUARY 2009)

APPENDIX A. TECHNICAL APPROVAL SCHEDULE "TAS" (NOVEMBER 2007)

SCHEDULE OF DESIGN DOCUMENTS RELATING TO HIGHWAY BRIDGES AND STRUCTURES

~~BS 5268~~	~~Part 2 : 2002~~	~~Structural Use of Timber~~
BS 5400		Steel, Concrete and Composite Bridges
	Part 1 : 1988	General Statement (see BD 15 (DMRB 1.3.2))
	Part 2 : 1978	Specification for Loads (as implemented by BD 37 (DMRB 1.3.14))
	Part 3 : 2000	CP for Design of Steel Bridges (see BD13 (DMRB 1.3.14))
	~~Part 4 : 1990~~	~~CP for Design of Concrete Bridges (see BD 24 (DMRB 1.3.1))~~
	~~Part 5 : 1979~~	~~CP for Design of Composite Bridges (see BD 16 (DMRB 1.3.14))~~
	~~Part 9 : 1983~~	~~Bridge Bearings (see BD 20 (DMRB 2.3.1))~~
	Part 10: 1999	CP for Fatigue (see BD 9 (DMRB 1.3.14))
~~BS 5628~~	~~Part 1 : 2005~~	~~Structural Use of Un-reinforced Masonry~~
	~~Part 2 : 2005~~	~~Structural Use of Reinforced and Prestressed Masonry~~
~~BS 5930~~	~~1999~~	~~Site Investigations~~
~~BS 6031~~	~~1981~~	~~Earthworks~~
~~BS 6779~~	~~Part 1 : 1998~~	~~Highway Parapets for Bridges and Other Structures~~
	~~Part 2 : 1991~~	~~Highway Parapets for Bridges and Other Structures~~
~~BS 7818~~	~~1995~~	~~Pedestrian Restraint Systems in Metal~~
~~BS 8002~~	~~1994~~	~~Earth Retaining Structures~~
~~BS 8004~~	~~1986~~	~~Foundations (see BD 74 (DMRB 2.1.8))~~
~~BS 8006~~	~~1995~~	~~Strengthened/Reinforced Soils and other Fills~~
~~BS 8118~~	~~1991~~	~~The Structural Use of Aluminium~~
~~BS EN1317-1-1998 Road Restraint Systems – Part 1~~		~~Terminology and General Criteria for Test Methods~~
~~BS EN1317-2-1998 Road Restraint Systems – Part 2~~		~~Performance Classes, Impact Test Acceptance Criteria and Test Methods for Safety Barriers~~
~~BS EN1317-3-2000 Road Restraint Systems – Part 3~~		~~Performance Classes, Impact Test Acceptance Criteria and Test Methods for Crash Cushions~~
~~DD ENV1317-4 Road Restraint Systems – Part 4~~		~~Performance Classes, impact test acceptance criteria and test methods for terminals and transitions of safety barriers~~
~~BS EN 14388 2005~~		~~Road traffic noise reducing devices- Specification~~
~~BS EN10113-1-1993~~		~~General Delivery Conditions~~
BS EN10113-2-1993		Delivery Conditions for Normalised Rolled Steel

~~BS EN10113-3-1993~~	~~Delivery Conditions for Thermomechanical Rolled Steel~~
~~BS EN 10155: 1993~~	~~Structural Steels with Improved Atmospheric Corrosion Resistance. Technical Delivery Conditions~~
~~BS EN 10210-1-2006~~	~~Hot Finished Structural Hollow Sections of Non-alloy and Fine Grain Structural Steels. Technical Delivery Conditions.~~
~~BS ISO 10005 : 1995~~	~~Quality Management – Guidelines for Quality Plans~~
~~prEN 10138-3 : 1991~~	~~Prestressing Steels – Strands~~

MISCELLANEOUS

~~Circular Roads No 61/72 - Routes for Heavy and High Abnormal Loads.~~

~~Railway Approved Code of Practice GC/RC5510: Recommendations for the Design of Bridges (2000) (for full list of other Network Rail Standards, refer to RSSB, Railway Safety and Standards Board)~~

~~Simplified Tables of External Loads on Buried Pipelines (1986) (published by TSO)~~

~~Traffic Management Act 2004~~

THE MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS (MCDHW)

Volume 1	Specification for Highway Works (Amendment November 2008)
Volume 2	Notes for Guidance on the Specification for Highway Works (Amendment November 2008)
Volume 3	Highway Construction Details (Amendment November 2008)

THE DESIGN MANUAL FOR ROADS AND BRIDGES (DMRB)

Bridges and Structures, Advice Notes (BA Series)

BA 9/81	The use of BS 5400: Part 10:1980. Code of Practice for Fatigue. Amendment No.1
~~BA 16/97~~	~~The Assessment of Highway Bridges and Structures. Amendment No. 2 Nov 2001~~
BA 19/85	The Use of BS 5400:Part 3:1982
~~BA 24/87~~	~~Early Thermal Cracking of concrete. Amendment No.1~~
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 30/94~~	~~Strengthening of concrete Highway Structures using Externally Bonded Plates~~
~~BA 34/90~~	~~Technical Requirements for the Assessment and Strengthening Programme for Highway Structures. Stage I Older short span Bridges and Retaining Structures~~
~~BA 35/90~~	~~Inspection and Repair of Concrete Highway Structures~~
~~BA 36/90~~	~~The Use of Permanent Formwork~~

~~BA 37/92~~	~~Priority Ranking of Existing Parapets~~
~~BA 38/93~~	~~Assessment of the Fatigue Life of Corroded or Damaged Reinforcing Bars~~
~~BA 39/93~~	~~Assessment of Reinforced Concrete Half-Joints~~
~~BA 40/93~~	~~Tack welding of Reinforcing Bars~~
~~BA 41/98~~	~~The Design and Appearance of Bridges~~
~~BA 42/96~~	~~The Design of Integral Bridges (Amendment No.1)~~
~~BA 43/94~~	~~Strengthening, Repair and Monitoring of Post-tensioned Concrete Bridge Decks~~
~~BA 44/96~~	~~Assessment of Concrete Highway Bridge and Structures~~
~~BA 47/99~~	~~Waterproofing and Surfacing of Concrete Bridge Decks~~
~~BA 50/93~~	~~Post-tensioned Concrete Bridges: Planning ,Organisation and Methods for Carrying Out Special Inspections~~
~~BA 51/95~~	~~The Assessment of Concrete Structures Affected by Steel Corrosion~~
~~BA 52/94~~	~~The Assessment of Concrete Highway Structures Affected by Alkali Silica Reaction~~
~~BA 53/94~~	~~Bracing Systems and the Use of U-Frames in Steel Highway Bridges~~
~~BA 54/94~~	~~Load Testing for Bridge Assessment~~
~~BA 55/06~~	~~The Assessment of Bridge Substructures and Foundations, Retaining Walls and Buried Structures~~
~~BA 56/96~~	~~The Assessment of Steel Highway Bridges and Structures~~
~~BA 57/01~~	~~Design for Durability~~
~~BA 58/94~~	~~Design of Bridges and Concrete Structures with External Unbonded Prestressing~~
~~BA 59/94~~	~~Design of Highway Bridges for Hydraulic Action.~~
~~BA 61/96~~	~~The Assessment of Composite Highway Structures~~
~~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~~
~~BA 80/99~~	~~Use of Rockbolts~~
~~BA 82/00~~	~~Formation of Continuity Joints in Bridge Decks~~
~~BA 83/02~~	~~Cathodic Protection for Use in reinforced Concrete Highway Structures~~
~~BA 84/02~~	~~Use of Stainless Steel Reinforcement in Highway Structures~~
~~BA 85/04~~	~~Coatings for Concrete Highway Structures & Ancillary Structures~~

~~BA 86/04~~	~~Advice Notes on Non-Destructive Testing of Highway Structures~~
~~BA 87/04~~	~~Management of Corrugated Steel Buried Structures (Correction No. 1)~~
~~BA 88/04~~	~~Management of Buried Concrete Box Structures~~
~~BA 92/07~~	~~The Use of Recycled Concrete Aggregates in Structural Concrete~~

Bridges and Structures, Standards (BD Series)

BD 2/05	Technical Approval of Highway Structures
~~BD 7/01~~	~~Weathering steel for highway structures~~
BD 9/81	Implementation of BS 5400: Part 10:1980. Code of Practice for Fatigue
~~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 13/06	Design of Steel Bridges. Use of BS 5400: Part 3: 2000
BD 15/92	General Principles for the Design and Construction of Bridges. Use of BS 5400: Part1: 1988
~~BD 16/82~~	~~Design Of Composite Bridges. Use of BS 5400:Part 5:1979 Amendment No.1~~
~~BD 20/92~~	~~Bridge Bearings. Use of BD 5400:Part 9:1983~~
~~BD 21/01~~	~~The Assessment of Highway Bridges and Structures. (May and August 2001 Amendments)~~
~~BD 24/92~~	~~Design of Concrete Bridges. Use of BS 5400:Part 4:1990~~
~~BD 27/86~~	~~Materials for the Repair of Concrete Highway Structures~~
~~BD 28/87~~	~~Early Thermal Cracking of Concrete (Amendment No.1)~~
~~BD 29/04~~	~~Design Criteria for Footbridges~~
~~BD 30/87~~	~~Backfilled Retaining Walls and Bridge Abutments~~
~~BD 31/01~~	~~The design of buried concrete box and portal frame structures~~
BD 33/94	Expansion Joints for Use in Highway Bridge Decks
~~BD 34/90~~	~~Technical Requirements for the Assessment and Strengthening Programme for Highway Structures. Stage 1 - Older Short Span Bridges and Retaining Structures~~
~~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
~~BD 41/97~~	~~Reinforced Clay Brickwork Retaining Walls of Pocket Type and Grouted Cavity type Construction – Use of BS 5628: Part 2: 1995~~
~~BD 42/00~~	~~Design of embedded retaining walls and bridge abutments~~
~~BD 43/03~~	~~The Impregnation of Reinforced & Pre-stressed Concrete Highway Structures using Hydrophobic Pore Lining Impregnants~~
~~BD 44/95~~	~~The Assessment of Concrete Highway Bridges and Structures~~
~~BD 45/93~~	~~Identification Marking of Highway Structures~~
~~BD 46/92~~	~~Technical Requirements for the Assessment and Strengthening Programme for Highway Structures. Stage 2 - Modern Short Span Bridges~~
~~BD 47/99~~	~~Waterproofing and Surfacing of Concrete Bridge Decks~~
~~BD 48/93~~	~~The Assessment and Strengthening of Highway Bridge Supports~~
~~BD 49/01~~	~~Design Rules for Aerodynamic Effects on Bridges~~
~~BD 50/92~~	~~Technical Requirements for the Assessment and Strengthening Programme for Highway Structures. Stage 3 - Long Span Bridges~~
~~BD 51/98~~	~~Design Criteria for Portal and Cantilever Sign/Signal Gantries~~
~~BD 53/95~~	~~Inspection & Records for Road Tunnels.~~
~~BD 54/93~~	~~Post-tensioned Concrete Bridges Prioritisation of Special Inspections~~
~~BD 56/96~~	~~The Assessment of Steel Highway Bridges and Structures~~
~~BD 57/01~~	~~Design for Durability~~
~~BD 58/94~~	~~The Design of Concrete Highway Bridges and Structures with External and Unbonded Prestressing Design of Highway Bridges for Vehicle Collision~~
~~BD 60/04~~	~~The Design of Highway Bridges for Vehicle Collision Loads~~
~~BD 61/96~~	~~The Assessment of Composite Highway Bridges~~
~~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 Protector Beams~~
~~BD 67/96~~	~~Enclosures 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 8006:1995) (Incorporating Amendment No.1)~~
~~BD 74/00~~	~~Foundations~~
~~BD 78/99~~	~~Design of Road Tunnels~~

~~BD 79/06~~	~~The management of sub-standard highway structures~~
~~BD 81/02~~	~~Use of compressive membrane action in bridge decks~~
~~BD 82/00~~	~~Design of buried rigid pipes~~
~~BD 84/02~~	~~Strengthening of Concrete Bridge Supports for Vehicle Impact Using Fibre Reinforced Polymers~~
~~BD 85/08~~	~~Strengthening Highway Structures Using Externally Bonded Fibre Reinforced Polymer~~
~~BD 86/04~~	~~The Assessment of Highway Bridges & Structure for Effects of STGO & SO Vehicles~~
~~BD 87/05~~	~~Maintenance Painting of Steelwork~~
~~BD 89/03~~	~~The Conservation of Highway Structures~~
~~BD 90/05~~	~~Design of FRP Bridges and Highway Structures~~
~~BD 91/04~~	~~Unreinforced Masonry Arch Bridges~~
~~BD 94/07~~	~~Design of Minor Structures~~
~~BD 95/07~~	~~Treatment of Existing Structures on Highway Widening Scheme~~

Bridges and Structures, Technical Memoranda (BE Series)

~~BE 5/75~~	~~Rules for the Design and Use of Freyssinet Concrete Hinges in Highway Structures~~
~~BE 7/04~~	~~Departmental Standard (Interim) Motorway Sign/Signal Gantries~~
~~BE 13~~	~~Fatigue Risk in Bailey Bridges~~
~~BE 23~~	~~Shear Key Decks (Amendment No. 1 to Annex dated June 1971)~~

Traffic Engineering and Control, Standards (TD Series)

~~TD 9/93~~	~~Highway Link Design (Amendment No.1)~~
~~TD 16/07~~	~~Geometric Design of Roundabouts~~
~~TD 19/06~~	~~Requirement for Road Restraint Systems~~
~~TD 27/05~~	~~Cross Sections and Headroom~~
~~TD 34/07~~	~~Design of Road Lighting for the Strategic Motorway and Trunk Road Network~~
~~TD 36/93~~	~~Subways for Pedestrians and Cyclists, Layout and Dimensions~~
~~TD 54/07~~	~~Design of Mini Roundabouts~~
~~TA 49/07~~	~~Appraisal of New and Replacement Lighting on the Strategic Motorway and All Purpose Trunk Road Network~~
~~TA 84/06~~	~~Code of Practice for Traffic Control & Information Systems for All-Purpose Roads~~
~~TA 89/05~~	~~Use of passively safe supports to BS EN 12767:2000~~

~~TA 90/05~~	~~The Geometric Design of Pedestrian, Cycle and Equestrian Routes~~

Highways, Advice Notes (HA Series)

~~HA 59/92~~	~~Mitigating Against Effects on Badgers~~
~~HA 65/94~~	~~Design Guide for Environmental Barriers~~
~~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~~
~~HA 207/07~~	~~Air Quality~~
~~HA 208/07~~	~~Cultural Heritage~~

Highways, Advice Notes (HD Series)

~~HD 22/02~~	~~Managing Geotechnical Risk~~
~~HD 29/08~~	~~Data for Pavement Assessment~~

ADDITIONAL RELEVANT STANDARDS

Interim Advice Notes (IAN)

~~01/95~~	~~TD 37/93 Scheme Assessment Reporting~~
~~03/96~~	~~BA 50/93 Post Tensioned Concrete Bridges~~
~~04/96~~	~~BD 44/95 The Assessment of Concrete Highway Bridges and Structures~~
~~05/96~~	~~BD 24/92 The Design of Concrete Highway Bridges and Structures. Use of BS 5400: Part 4: 1990.~~
~~36/01~~	~~The Use and Application of Micro-Simulation Traffic Models~~
~~39/01~~	~~Post Opening Project Appraisal (POPE)~~
~~41/02~~	~~European Cement Standards~~
~~47/02~~	~~Post Tensioned Grouted Duct Concrete Bridges~~
~~48/03~~	~~Measures to Minimise the Risk of Sulphate Attack (Including Thaumasite) — New Construction and Structures Under Construction~~
~~49/03~~	~~Use of Warning Signs for New Asphalt Road Surfaces~~
~~51/03~~	~~Hinge Deck Structures~~
~~53/04~~	~~Concrete Half-joint Deck Structures~~
~~56/04~~	~~Maintenance of Traffic Signs with Dew Resistant Coatings~~
~~63/05r1~~	~~Asbestos Management Applicable to the Strategic Road Network~~
~~64/05~~	~~Driver Information at Road Works~~
~~68/05~~	~~Infrastructure Changes to Improve Emergency Access to and Egress from the Trunk Road Network in England~~
~~69/05~~	~~Designing for Maintenance~~
~~70/06~~	~~Implementation of New Reinforcement Standards (BS 4449:2005, BS 4482:2005, BS 4483:2005 and BS 8666:2005)~~
~~71/06~~	~~Marker Posts on Lay-by Segregation Islands~~
~~73/06~~	~~Design of Pavement Foundations~~
~~75/06~~	~~Code of Practice for Emergency Access To and Egress from the Trunk Road Network in England~~
~~83/06~~	~~Principal and General Inspection of Sign/Signal Gantries, and Gantries with low handrails or open mesh flooring~~
~~84/07~~	~~Highways Agency Environmental Information System - EnvIS~~
~~85/07~~	~~Design of Passively Safe Portal Signal Gantries~~

~~86/07~~	~~Amendments to Design Requirements for Portal and Cantilever Sign/Signal Gantries~~
~~87/07~~	~~The Provision of Signal Gantries for Motorways with Four or More Running Lanes~~
~~90/07~~	~~Guidance For The Use Of Rapid Setting Emergency Repair Materials (Amendment 1)~~
~~91/07~~	~~Interim Advice on the Identification of "Particularly at Risk" Supports~~
~~93/07~~	~~Driver location signs - Interim Performance Specification~~
~~95/07~~	~~Revised Guidance Regarding the use of BS8500 (2006) for the Design and Construction of Structures Using Concrete~~
~~96/07r1~~	~~Guidance on Implementing Results of Research on Bridge Deck Waterproofing~~
~~97/07r1~~	~~Assessment and Upgrading of Existing Vehicle Parapets~~
~~98/07~~	~~Guidance for HA Service Providers on Implementing the Skid Resistance Policy~~
~~99/07~~	~~Implementation of Local Grid Referencing System for England~~
~~100/07~~	~~Cultural Heritage Asset Management Plans~~
~~103/08~~	~~Advice Regarding the Assessment of Site for Ramp Metering~~
~~104/07~~	~~The Anchorage of Reinforcement & Fixings in Hardened Concrete~~
~~105/08~~	~~Implementation of Construction (Design and Management) 2007 and the withdrawal of SD 10 and SD 11~~
~~106/08~~	~~Guidance Note For Traffic Consultants Working On HA Schemes~~
~~107/08~~	~~Variable Demand Modelling As Part of a Transport Assessment for the Highways Agency~~
~~109/08~~	~~Advice regarding the Motorway Signal Mark 4 (MS4)~~
~~110/08~~	~~Assessment of Implications (of Highways Plans or Projects) on European Sites (Including Appropriate Assessment)~~
~~111/08~~	~~Managed Motorway Implementation Guidance – Dynamic Use of the Hard Shoulder [PR 99/08]~~
~~112/08~~	~~Managed Motorway Implementation Guidance – Through Junction Hard Shoulder Running [PR 100/08]~~
~~113/08~~	~~Temporary Automatic Speed Camera System for the Enforcement of Mandatory Speed Limits at Roadwords (TASCAR)~~
~~114/08~~	~~Highways Agency Carbon Calculation and Reporting Requirements~~
~~115/08~~	~~Guidance For Works On The Hard Shoulder And Road Side Verges On High Speed Dual Carriageways~~
~~116/08~~	~~Nature Conservation Advice In Relation To Bats~~
~~117/08~~	~~Certification of Combined Kerb and Drainage Products~~

APPENDIX B

DRAWING No 5057541/314/100

DRAWING No 5057541/314/101

DRAWING No 5057541/314/102

DRAWING No 5057541/314/103

APPENDIX C

HAZARD IDENTIFICATION AND RISK ASSESSMENTS

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