

Infrastructure Investment Civils
Network Rail
Kings Place
90 York Way
London
N1 9AG

Standard Design Details Underbridges – E-Type

ELR: Site Specific Details to Be Provided

FORM A – APPROVAL IN PRINCIPLE ADDENDUM: EUROCODE DESIGN

6th November 2009

.....



St Anne House
20-26 Wellesley Road
Croydon
Surrey
CR9 2UL
Tel 020 8774 2000
Fax 020 8681 5706

Form A: Approval in Principle Addendum: Eurocode Design

Title of Scheme: Standard Design Details Underbridges – E-Type					
Location: <i>Site Specific Details to Be Provided</i>					
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC
				Structure No.	TBC

Mott MacDonald

Form A: APPROVAL IN PRINCIPLE ADDENDUM:

EUROCODE DESIGN

Standard Design Details Underbridges – E-Type

ELR:	<i>Site Specific Details to Be Provided</i>
CHAINAGE:	<i>Site Specific Details to Be Provided</i>
BRIDGE NO:	<i>Site Specific Details to Be Provided</i>
OS Map Ref:	<i>Site Specific Details to Be Provided</i>

Issue and Revision Record:

Rev:	Date	Originator	Checker	Approver	Description
A	06/11/09	I J Palmer	M J Kynoch	A G Wilkins	First issue

This document has been prepared for the titled project or named part thereof and should not be relied upon or used for any other project without an independent check being carried out as to its suitability and prior written authority of Mott MacDonald being obtained. Mott MacDonald accepts no responsibility or liability for the consequence of this document being used for a purpose other than the purposes for which it was commissioned. Any person using or relying on the document for such other purpose agrees, and will by such use or reliance be taken to confirm his agreement to indemnify Mott MacDonald for all loss or damage resulting therefrom. Mott MacDonald accepts no responsibility or liability for this document to any party other than the person by whom it was commissioned.

To the extent that this report is based on information supplied by other parties, Mott MacDonald accepts no liability for any loss or damage suffered by the client, whether contractual or tortious, stemming from any conclusions based on data supplied by parties other than Mott MacDonald and used by Mott MacDonald in preparing this report.

Form A: Approval in Principle Addendum: Eurocode Design

Title of Scheme:		Standard Design Details Underbridges – E-Type			
Location:		Site Specific Details to Be Provided			
<i>ELR</i>	<i>TBC</i>	<i>Mileage</i>	<i>TBC</i>	<i>OS Grid Ref</i>	<i>TBC</i>
				<i>Structure No.</i>	<i>TBC</i>

Introduction

This addendum covers the verification of the E-Types standard design details in accordance with the structural Eurocodes, associated National Annexes and published documents.

Details are provided in the following appendices:

- APPENDIX A: Standards and Other Documents
- APPENDIX B: List of Values and Approaches where values or choices other than those in the UK National Annex recommended values or approaches are proposed for SDD.

A summary of the key Values and Approaches where National Choice is allowed or individual projects may determine follows and summarises:

- Principal approaches.
- Basic load information.
- Load and combination factors.
- Other Aspects where Choice is Permitted in the Eurocode and UK National Annexes.

Principal approaches.

BS EN 1990. Equation 6.10 to be used for combining actions for the ULS.

The design life of the structure for FAT verification is 120 years.

Basic load information.

BS EN1991-1-1. Densities and weights of materials:

Eurocode & National Annex BS EN1991-1		
Material	Ballast	21kN/m ³
	Steel	77kN/m ³
	Concrete	25kN/m ³
	Track	6kN/m

Note that the track weight includes sleeper and rail only, i.e. no allowance for ballast in between sleepers.

Form A: Approval in Principle Addendum: Eurocode Design

Title of Scheme: Standard Design Details Underbridges – E-Type					
Location: <i>Site Specific Details to Be Provided</i>					
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC
Structure No.		TBC			

Load and combination factors.

The following table summarises the partial load factors and application of BS EN1992-1 cl. 6.3.2(3)P factor α :

Eurocode & Nation Annex BS EN1990 BS EN1991-2		Ultimate Limit State		Serviceability Limit State		Fatigue		Deformation	
		Permanent/Transient							
		γ	α	γ	α	γ	α	γ	α
Permanent	Track	1.35	-	1.00	-	-	-	-	-
	Ballast	1.35	-	1.00	-	-	-	-	-
	Parapets	1.35	-	1.00	-	-	-	-	-
	Steel	1.20	-	1.00	-	-	-	-	-
	Concrete	1.35	-	1.00	-	-	-	-	-
	Superimposed Permanent Load incl. Cables, Waterproofing	1.35	-	1.00	-	-	-	-	-
Variable	LM71	1.45	1.21	1.25	1.00	1.00	1.00	1.00	1.00
	Traction/Braking	1.45	1.21	1.25	1.00	1.00	1.00	1.00	1.00
	Centrifugal	1.45	1.21	1.25	1.00	1.00	1.00	1.00	1.00
	Nosing	1.45	1.21	1.25	1.00	1.00	1.00	1.00	1.00
	Walkway	1.35	-	1.15	-	-	-	-	-
	Wind	1.70	-	1.00	-	-	-	-	-
	Thermal	1.55	-	1.00	-	-	-	-	-

The combination factors are given in BS EN 1990 Annex A2 (final draft dated 11th March 2009). The National Annex has not been published but work undertaken by Network Rail, RSSB and Mott MacDonald concluded that the factors given in the published Eurocode should be used. Therefore the combination factors to be used for the standard underbridge design verification will be as in BS EN 1990. All other National Annexes have been published and the factors and approaches therein will be used.

Rail crane actions: The rail crane shall be placed on structures in accordance with NR/L2/CIV/020 (draft 12) with the gamma (γ) factor equal to 1.40. The coexistent railway actions γ factor is as specified above. No dynamic factor or alpha (α) factor shall be applied to either the rail crane or the coexistent railway actions.

Other Aspects where Choice is Permitted in the Eurocode and UK National Annexes.

The dynamic factor for both shear and bending effects due to transient (railway) load will be factored by Φ_3 at ULS and SLS in accordance with NA BS EN 1991-2 cl. 6.4.5.2 (3)P.

For FAT verification, the dynamic factor for both shear and bending effects due to transient (railway) load will be factored by Φ_2 in accordance with BS EN 1993-2 cl. 9.2.3(1).

NA BS EN 1991-2 requirements for traction and braking loads to be considered and the worst case of the Eurocode and the National Annex values to be used in the design.

NA BS EN 1993-1-9 FAT categories to be used.

Vibration and deformation checks are to be in accordance with NR/L2/S/020 (draft 12).

Form A: Approval in Principle

Title of Scheme: Standard Design Details Underbridges – E-Type							
Location: Site Specific Details to Be Provided							
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC	Structure No.	TBC

Changes to Form A revision B (originated 9th February 2009)

Changes from Revision B of the Form A originated 9th February 2009

(Details remain unchanged unless details given here)

1.8 Design Criteria (underline bridge)

1.8.1 Design railway loading

LM71 Railway loading.

A factor, α , applied where railway traffic could be heavier than normal european traffic, is mandated in draft TSIs as 1,10 and shall apply. Draft Network Rail specification NR/L2/CIV/020 also requires an additional factor for deterioration, $\gamma_{det} = 1,10$. The net factor to apply to LM71 is the product of the two = 1,21 and shall be referred to as α .

Rail traffic actions will be positioned in the most onerous position for the element considered.

The maximum centrifugal force to be considered will be $Q_{tk} = 0,20Q_{vk}$.

100% of the longitudinal loads resulting from traction and braking are to be sustained by the bridge: No transfer to the adjacent infrastructure shall be considered.

In addition to the standard railway design loading, the following nominal loading for a KIROW KRC1200UK rail mounted crane shall be taken into account in the design:
Loads: 8 number point loads each of 250kN on each of 2 rails

Spacings: 1100 1200 1100 5600 1100 1200 1100 mm
The 16 No point loads (8 axles) shall be applied with a dynamic factor of 1,0 (i.e. there is no increase in the loads for dynamic effects) and the loading is not to be considered for fatigue checks.

The crane loading shall be applied as an alternative to LM71 loading on one track, with normal railway loading (LM71, SW/o etc.) applied on the adjacent track(s). The crane loading shall be applied as the leading action with the following factors applied:

$\gamma_Q = 1,40$ on the crane load

$\gamma_Q = 1,45$ on the coexistent railway load

$\alpha = 1,00$

Impact factors on coexistent railway load = 1,00

Form A: Approval in Principle

Title of Scheme: Standard Design Details Underbridges – E-Type							
Location: Site Specific Details to Be Provided							
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC	Structure No.	TBC

1.8.2	Traffic type for fatigue	The standard designs will consider the light traffic mix (Type 9 multiple units), standard traffic mix (EC1 mix) and traffic with 250kN (25t) axles
1.8.3	Actual annual traffic tonnage per track	Not applicable as the standard designs are not site specific.
1.8.4	Design annual traffic tonnage per track for fatigue	The standard designs will consider four cases; 7 - 12x10⁶t/annum, 12 - 18x10⁶t/annum, 18 - 27x10⁶t/annum and 27 - 42x10⁶t/annum. Where the fatigue assessment is undertaken in accordance with BS EN 1993-2, the damage equivalence factor λ_2 for the annual traffic tonnage will be interpolated from the values given in table 9.5. The standard designs will therefore be suitable for locations where the predicted annual traffic tonnage is equal to but does not exceed 42x10⁶t/annum. Where shallow girder flange plate thicknesses would be uneconomical for universal application and for longer span decks subject to heavy traffic will be designed for a reduced, span dependent annual traffic tonnage.
1.8.5	Rail traffic Design speed	The standard designs will be suitable for locations where the design speed does not exceed 200km/h (passenger traffic) or 120km/h (freight traffic).
1.8.6	Design footway/ walkway loading	Unchanged.
1.8.7	Minimum ballast depth/sleeper type	The standard designs will consider a minimum desired ballast depth of 200mm and a maximum desired ballast depth of 400mm (average) below the sleeper and the deck. NA BS EN1991-1-1 table NA.1 requires an allowance of $\pm 30\%$ in the ballast depth below sleeper. Where the ballast depth >300mm, the $\pm 30\%$ allowance is applied to the top 300mm of ballast only. Ballast density assumed to be 21kN/m³. The assumed track make up (rail, sleeper and chair) is 368mm. The design will assume the maximum sleeper width that may be placed on the bridge without modification of the sleeper is the width of an EF28 sleeper: 2580mm. Track weight assumed to be 6kN/m per track noting that this includes sleeper and rail only, i.e. no allowance for ballast in between sleepers.
1.8.8	Track lift and/or realignment	Unchanged.
1.8.9	Construction depth (top of highest rail to soffit) and headroom to be provided	Unchanged

2016/03/27/2016 21:52:48 MDT

Form A: Approval in Principle

Title of Scheme: Standard Design Details Underbridges – E-Type							
Location: Site Specific Details to Be Provided							
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC	Structure No.	TBC

1.8.10 Other Criteria

The standard E type will be designed to be used anywhere on the UK railway network. The deck type is considered a type 1 detail in BS EN 1991-5 and as such the minimum effective bridge temperature shall be -24°C and the maximum effective bridge temperature shall be 39°C (based on a 50 year return period). Note that NR/L2/CIV/020 (draft 12) requires an addition of 10°C to the maximum effective bridge temperature stated here and this addition will be allowed for in the design.

The fundamental basic wind velocity shall be 29m/s.

An allowance of 1kN/m^2 is assumed for the deck waterproofing. $\gamma_G = 1,35$ and $1,00$ shall be applied at ULS and SLS respectively.

Limits on deformations shall be in accordance with BS EN 1990 Annex A2. The speed range to be considered will be up to 200kph. Allowable deflections for passenger comfort will be considered for a 'very good' level of comfort, i.e. the limits in figure A.2.3 of BS EN 1990 will not be exceeded.

Where the short span decks remain too stiff, i.e. their natural frequency too high and above the upper bound values in figure 6.10 of BS EN 1991-2, a dynamic factor of 2,0 shall be applied. A dynamic analysis will not be undertaken as studies have shown that for half through structures the high frequency dynamic effects are not significant.

The flanges and webs of deep girders will be designed to act as a robust kerb. The design will assume a vertical distance between the flange and rail level of 350mm. The scheme designer must choose the relevant main girder depth to ensure that the minimum level difference between the flange and the rail is at least 350mm, to allow for the likelihood of future track lifts and account for construction tolerance.

U frame stiffener rotation at connection assumes $0,2 \times 10^{-10}$ rad/Nmm and $0,5 \times 10^{-10}$ rad/Nmm for a six and four bolt connection respectively.

1.18 Design life

120 years

1.19 Organisation proposed to be responsible for detailed Design

Unchanged.

1.20 Design Standards and Published Documents

The standard designs will be undertaken in accordance with the list of standards and codes in Appendix C of this Form A Addendum.

Form A: Approval in Principle

Title of Scheme: Standard Design Details Underbridges – E-Type							
Location: <i>Site Specific Details to Be Provided</i>							
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC	Structure No.	TBC

The standards and codes current on 22nd October 2009 will be used.

1.21 Departures from Design Standards and Published Documents

None

1.25 Any other relevant information

1.25.1 Matters not covered by Design Standards.

1. The structural Eurocodes do not cover the design of bearings. There are no changes from the design approach described in the original Form A.

2. The consequence class is medium, i.e. CC2. It is assumed that steelwork will be fabricated in accordance with BS EN 1090-2 and the execution class equivalent to BS EN ISO 5817 quality level B, i.e. EXC 3. In the absence of the execution standard BS EN 13670 (concrete) it is assumed that execution will be in accordance with Network Rail's model clauses for specifying railway works. The consequence class for the standard designs will be Where tolerances assumed in the design are less than allowed in execution, the required tolerances will be shown on the standard drawings and in the technical user manual.

3. Composite design (filler beam floor). BS EN 1994-2 does not give rules for fully encased beams. The filler beam floor detail developed for the E Types over many years considers a fully encased section within the concrete. The concrete below the bottom flange and the concrete in net tension will be neglected and the rules for an exposed bottom flange will apply.

1.25.2 Methodology for the calculation of U frame restraint forces.

1. It is proposed to calculate the restraint force provided by U frames to the main girder compression flange from first principles in accordance with the general rules in BS EN 1991-1-1 (cl. 6.3.4.1). The Form B submission will identify and include references justifying the use of these rules, that are replicated in BS 5400 part 3:2000.

Form A: Approval in Principle

Title of Scheme:		Standard Design Details Underbridges – E-Type	
Location:		Site Specific Details to Be Provided	
ELR	TBC	Mileage	TBC
OS Grid Ref		TBC	
Structure No.		TBC	

Certificates

Part 2: Designer Submission

I confirm that the applicable criteria specified in Network Rail Company Specification NR/SP/CIV/003 have been considered, and the Design is submitted for Approval in Principle on behalf of **Mott MacDonald**.

Signed		Title	PROJECT DIRECTOR
Name	A.G. WILKINS	Date	06 NOVEMBER 09
To be signed by the Designer responsible for the Design to AIP stage or other person authorised to sign on behalf of the organisation responsible for the Design			

Part 3: Construction organisation acknowledgement of submission by a sub-contract Designer

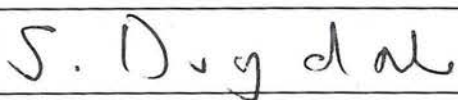
The organisation named in Part 2 is engaged as a sub contractor to the organisation stated below. I formally acknowledge the submission of this certificate to Network Rail in support of our contract/sub-contract* obligation for provision of the AIP stage Design on behalf of:
(* Delete as applicable)

Signed	Title
Name (Print)	Date
To be signed by the Contractor's Responsible Engineer or other person authorised to sign on behalf of the organisation responsible for the Construction Works	

Part 4: Designated Project Engineer Comments

I have considered the submission for the above Scheme and confirm that the information specified in Network Rail Company Specification NR/SP/CIV/003 is included in the submission. My comments on the submission are as shown below.

REFER TO GENERAL DPE SIGN OFF COMMENTS
FOR BS 5400 VERSION DATED 22ND MAY 2009

Signed		Title	PROJECT ENGINEER
Name (Print)	S. DUGDALE	Date	29th JANUARY 2010.
To be signed by the Designated Project Engineer			

Form A: Approval in Principle

Title of Scheme:		Standard Design Details Underbridges – E-Type	
Location:		Site Specific Details to Be Provided	
ELR	TBC	Mileage	TBC
OS Grid Ref		TBC	
Structure No.		TBC	

Part 5: Civil Engineer comments

I have considered the submission for Approval in Principle of the above Scheme in order to be satisfied that the Designer has adequately addressed the applicable criteria specified in Network Rail Company Specification NR/SP/CIV/003, and confirm that:

The Design of the permanent works shall be checked as **category 3**.

~~The Design of the Temporary Works shall be checked as category 3.~~

The Scheme does/does not* require endorsement by Network Rail's Professional Head of Structures Engineering in accordance with Network Rail Company Specification NR/SP/CIV/003.

(* Delete as applicable)

My comments on the submission are as shown below. Provided these comments are adequately addressed, I hereby give Approval in Principle to the Scheme.

Signed		Title	Senior Design Engineer
Name (Print)	ALAN DRAY	Date	29-01-10
To be signed by the Civil Engineer			

Signed	Title
Name (Print)	Date
To be signed by other responsible person (if applicable)	

Form A: Approval in Principle

Title of Scheme:		Standard Design Details Underbridges – E-Type			
Location:		Site Specific Details to Be Provided			
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC
Structure No.		TBC			

Part 6: Asset Engineer Endorsement

I have considered the submission for the above Scheme and confirm that the information specified in Network Rail Company Specification NR/SP/CIV/003 is included in the submission. My comments on the submission are as shown below

N/A
L.S.

Signed	Title
Name (Print)	Date
To be signed by the Asset Engineer	

Part 7: Endorsement by Network Rail's Professional Head of Civil Engineering

I have considered the submission for Approval in Principle of the above Scheme as required by the Network Rail Company Specification NR/SP/CIV/003 in order to be satisfied that the applicable criteria specified in Network Rail Company Specification NR/SP/CIV/003 have been adequately addressed by the Designer, and my comments on the submission are as below.

Provided these comments are adequately addressed I hereby endorse the Approval in Principle submission.

None. L. B. Smith.

Signed	Title
Name (Print)	Date
To be signed on behalf of Network Rail's Professional Head of Structures Engineering	

(Handwritten: L. B. Smith, Principal Engineer (Structures), 22 Feb. 2010.)

Form A: Approval in Principle

Title of Scheme:		Standard Design Details Underbridges – E-Type					
Location:		<i>Site Specific Details to Be Provided</i>					
<i>ELR</i>	<i>TBC</i>	<i>Mileage</i>	<i>TBC</i>	<i>OS Grid Ref</i>	<i>TBC</i>	<i>Structure No.</i>	<i>TBC</i>

Appendix A

Standards and Other Documents used in Verification of the Designs to the Eurocodes

Form A: Approval in Principle

Title of Scheme: Standard Design Details Underbridges – E-Type							
Location: Site Specific Details to Be Provided							
ELR	TBC	Mileage	TBC	OS Grid Ref	TBC	Structure No.	TBC

LIST OF ADDITIONAL STANDARDS/CODES TO BE USED IN DESIGN**A EUROCODES**

Doc No.	Issue Date	Issue	Document Title
BS EN 1990	April 2002	+A1	Eurocode - Basis of structural design (+A1:2005) (incorporating corrigendum December 2008) (<i>note Annex A2 included</i>)
BS EN 1991-1-1:2002	July 2002	-	Eurocode 1: Actions on Structures – Part 1-1: General Actions – Densities, Self-weight, Imposed Loads for Buildings
BS EN 1991-1-3:2003	July 2003	-	Eurocode 1 — Actions on structures — Part 1-3: General actions — Snow loads
BS EN 1991-1-4:2005	April 2005	-	Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions
BS EN 1991-1-5:2003	March 2004	-	Eurocode 1: Actions on structures — Part 1-5: General actions — Thermal actions
BS EN 1991-2:2003	October 2003	-	Eurocode 1: Actions on Structures – Part2: Traffic Loads on Bridges
BS EN 1992-1-1:2004	December 2004	-	Eurocode 2: Design of Concrete Structures Part 1-1: General Rules and Rules for Buildings
BS EN 1992-2:2005	December 2005	-	Eurocode 2: Design of Concrete Structures Part 2: Concrete Bridges Design and Detailing Rules
BS EN 1992-3:2006	July 2006	-	Eurocode 2: Design of Concrete Structures Part 3: Liquid Retaining and Containment Structures
BS EN 1993-1-1:2005	May 2005	-	Eurocode 3: Design of Steel Structures - Part 1-1: General Rules and Rules for Buildings
BS EN 1993-1-5:2006	November 2006	-	Eurocode 3: Design of Steel Structures - Part 1-5: Plated Structural Elements
BS EN 1993-1-8:2005	May 2005	-	Eurocode 3: Design of Steel Structures - Part 1-8: Design of Joints
BS EN 1993-1-9:2005	May 2005	-	Eurocode 3: Design of Steel Structures - Part 1-9: Fatigue

2016/03/27 11:52:48 MDT