

**TECHNICAL USER MANUAL
for
STANDARD HALF THROUGH UNDERBRIDGES E-TYPE

Standard Detail and Design Drawings**

Copyright Network Rail
Provided by IHS under license with Network Rail
No reproduction or networking permitted without license from IHS

Summary

This technical user manual is applicable to the standard E-type half through underbridges. It provides guidance on the selection and application of Network Rail's suite of standard drawings. The standard designs and details within these drawings will generally be used for new-build structures, and part replacement e.g. deck replacement.

Issue record

This technical user manual will be updated when necessary by distribution of a complete replacement. A vertical black line in the margin will mark amended or additional parts of revised pages.

Revision	Date	Comments
A	August 2009	Issue for review
B	September 2009	Issue for review
C	November 2009	First Issue
D	May 2010	Second Issue – Eurocode update

CONTENTS

1	INTRODUCTION TO STANDARD DESIGNS AND DETAILS	7
1.1	Network Rail's Requirements	7
1.1.1	Delivery Requirements	7
1.1.2	Functional Requirements	7
2	GUIDANCE FOR USE OF NETWORK RAIL STANDARD DESIGNS AND DETAILS	9
2.1	Approval of Schemes Using Standard Designs & Details	10
2.2	Modifications to Standard Designs & Details	12
3	E-TYPE UNDERBRIDGE APPLICATION DETAILS	13
3.1	Check List of Standard and Non-Standard Items	14
3.2	Drawing Selection Flowchart	16
4	DETAILS OF STRUCTURAL FORM	19
4.1	Geometry and Configuration	19
4.2	Span	19
4.3	Skew	20
4.4	Floor Type	20
4.5	Floor Width	20
4.6	Construction Depth	21
4.7	Clearances	21
4.7.1	Structure Gauge Clearances	21
4.7.2	Static Electrical Clearances	22
4.7.3	Clearance Limits Affecting Design.	22
4.8	Track Arrangement	23
4.9	Cant and Deck Super Elevation	23
4.10	Ballast Depth	24
4.11	Sleeper and Rail Details	24
4.12	Site Constraints	24
4.13	Direct Fastening Systems	24
5	INSTALLATION GUIDANCE	25
5.1	Trial Erection	25
5.2	Installation Tolerances	25
5.3	Installation Guidance	25
5.3.1	Installation Using SPLV	26
5.3.2	Installation Using Cranes	26

5.4	Check List for Installation Options	26
6	GUIDANCE FOR USE OF THE E-TYPE STANDARD DESIGNS AND DETAILS	29
6.1	General Arrangement Drawing	29
6.2	General Assembly Drawings	29
6.3	Additional Consideration for Steel Floors	32
6.4	Details Drawings	32
6.4.1	Skew	32
6.4.2	Traffic	33
6.5	Main Girders	33
6.6	Bearings	34
6.7	Concrete and Reinforcement Drawing	34
6.8	Bar Bending Schedules	35
6.9	Protective Treatment and Waterproofing	35
6.9.1	Basic Principles and General Comments	35
6.9.2	Protective Treatment	36
6.9.3	Waterproofing	37
6.10	Drainage	37
6.11	Substructure and Ancillary Items	37
6.12	Bonding / Stray Current / Insulation	38
7	FABRICATION AND CONSTRUCTION	39
7.1	Fabrication	39
7.2	Construction	39
8	SAFETY / CDM AND ENVIRONMENTAL	40

LIST OF APPENDICES

APPENDIX A Schedule Of Standard Drawings

APPENDIX B History

APPENDIX C Design Assumptions

APPENDIX D Technical Details

APPENDIX E Hidden Parts

APPENDIX F Draft 12 of NR/L2/CIV/020 Design of Bridges & Culverts

LIST OF FIGURES

Figure 1: Flowchart to show the use of Network Rail's Standard Details and Designs	9
Figure 2: Process using the Standard Drawings and Technical User Manuals	12
Figure 3: List of Standard and Non-Standard Items, Design Responsibilities and Notes	15
Figure 4: Process to determine the Standard Details and Designs to use in detailing a Standard E-type Underbridge	17

Figure 5: Construction Depth	21
Figure 6: Cant Effects	23
Figure 7: Definition of Skews	30
Figure 8: Cross Girder / Transverse Rib Setting Out	32
Figure 9: Traffic Type and Detail Classification	33

GLOSSARY

Abutment	Part of the bridge structure that supports the bearings at the end of a deck and often supports and retains the approach embankment.
Bearing	The elements between the impost / cill and the main girders on which the deck is supported.
Bridge	A deck and its supporting structure (e.g. impost / cill, abutment or piers).
Cill	Alternative name for impost. The (usually) concrete beam on which the lower part of the bridge bearings are located.
Composite	A steel and concrete floor arrangement comprising transverse spanning steel sections acting compositely with a concrete slab above.
Deck	A pair of main girders and a floor.
Designer	The person responsible for selecting the relevant standard designs and details to suit the specific requirements for a particular scheme.
E-type	A standard underbridge arrangement comprising a pair of fabricated I shaped main girders, a floor, four main girder bearings and possibly bearings supporting an independent trimmer girder.
Filler Beam	A steel and concrete floor arrangement comprising transverse spanning steel sections encased within and acting compositely with a concrete slab.
Floor	The transverse element that supports the ballast and track. May comprise filler beams composite with concrete slab, or steel transverse ribs and steel plate.
Gauging Diagram	A diagram showing the clearances between the lower sector structure gauge and the proposed structure.
Impost	Alternative name for cill. The (usually) concrete beam on which the lower part of the bridge bearings are located.

Main Girder	The primary load sustaining element that spans between bearings and supports the floor. Comprises a pair of flanges, possibly flange doubler plates, a web, web stiffeners and bearing stiffeners. The girder is symmetrical about the centre line of the web.
Pier	Part of the bridge structure that supports the bearings at the end of a deck. Generally used where more than one span, in between abutments.
Protective Treatment	A treatment applied to structural elements to protect them from environment.
Scheme	Any planned work that involves the replacement of an existing bridge or deck.
Transverse Rib	A steel transverse member formed of a tee rib.
Trimmer Beam	The first cross member adjacent to the main girder bearings. May or may not support the trimmed ends at adjacent cross members.
TUM	Technical User Manual
SDD	Standard Designs and Details
Walkway	A standard detail comprising brackets attached to web stiffeners and longitudinal spanning members positioned to allow railway personnel traverse the bridge away from the track.
Waterproofing	Measures applied to handle and remove water off the deck and away from structural elements.

1 INTRODUCTION TO STANDARD DESIGNS AND DETAILS

The development of the Standard Designs and Details (SDD) has been undertaken by Network Rail to improve safety, asset reliability and increase efficiency. Their development is linked to Network Rail's overall business objectives, to improve reliability of the railways and reduce the funding requirements for on-going management and maintenance of the network. The basis of the SDD focuses on two main areas that derive from these issues:

- Ensuring that the design meets Network Rail's requirements
- The design is as successful as the designs of previous railway engineers, who built and maintained bridges that have given good service for approaching 150 years.

The use of the SDDs is promoted from the highest level within Network Rail. Alternatives to the SDDs will only be considered where it can be demonstrated that a SDD cannot be used and must be agreed with Network Rail's professional head of civil engineering. Failure to use a SDD may lead to project authority being withheld.

1.1 Network Rail's Requirements

Network Rail's requirements are split between two areas, delivery and function:

1.1.1 Delivery Requirements

The SDDs have been taken to a stage where Form As and Form Bs for each aspect covered (underbridge design, ancillaries etc.) have been submitted and approved. This leads to the following benefits:

- A reduction in the design development timescales and costs.
- Minimising contractor and sub-contractor costs associated with uncertainties in detailing requirements.
- Streamlining the technical approval process for commonly used designs and details.

1.1.2 Functional Requirements

The SDD have been designed to ensure satisfactory performance of the asset under both normal operations and abnormal operations (both planned and unplanned). A further consideration has been Network Rail's requirement to reduce the volume of maintenance and management costs through the adoption of good practice. This leads to a number key design drivers including:

- Failure modes: Critical failure modes should give warning, and alternative load paths should be provided for potential local failures.
- No hidden details: All main structural elements should be visible from at least one side.
- Robustness: It is desirable for elements of the structure to have a degree of robustness so that they are not damaged by unforeseen events disproportionate to the cause.
- Capability to support load.
- Acceptable deformations.
- Structure gauge requirements: The underbridges have been designed to cater for a range of positions of the structure gauge allowing their wide use.
- Safe working environment: The bridges have been designed to minimise the risk to people on or about the bridge.
- Resistance to “bridge bash”: The bridges have been designed to minimise the risk of catastrophic failure in the event of a “bridge bash”.
- Resistance to derailment: The bridges have been designed to cater for the codified derailment loads, as well as protecting the structure whilst mitigating damage to the surrounding structures.

These functional requirements are requirements of draft Network Rail standard NR/L2/CIV/020. Draft 012 of this standard has been used and the requirements therein met in designing the standard E-type details.

A library of standard designs and details for a range of half through underbridges forms meeting these requirements has been produced. This document contains guidance on the use of these standard drawings, including advice on the following:

- The elements and options contained within the suite of standard designs and details.
- Instruction on configuring a design using the standard designs and details
- Specific design restrictions and design assumptions
- Installation guidance
- Safety / CDM / environmental issues

The library will be maintained and distributed by Network Rail to its stakeholders and key external suppliers for adoption across the network at a national level.

2 GUIDANCE FOR USE OF NETWORK RAIL STANDARD DESIGNS AND DETAILS

The underlying philosophy of this standard is that a single standard floor design is provided, together with preferred details of the other components (i.e. main girders, bearings, walkways, protective treatment, waterproofing etc.) which go to make up a standard E-type bridge superstructure.

This allows the designer to produce a specific bridge design to suit the particular span, skew, track geometry, cable ducting and walking route requirements of any particular location with the minimum of design and drawing time, so long as they are within the limits of validity of the standard.

The flowchart in Figure 1 demonstrates the use of the technical user manual and standard drawings. The designer should analyse the constraints and requirements that exist for the specific project site. This information should be used in conjunction with the design advice contained within the technical user manual, to decide which elements can be taken from the suite of standard designs and details and which items, if any, need bespoke design. This designer output, and the series of standard drawings can be combined to produce the final E-type underbridge solution.

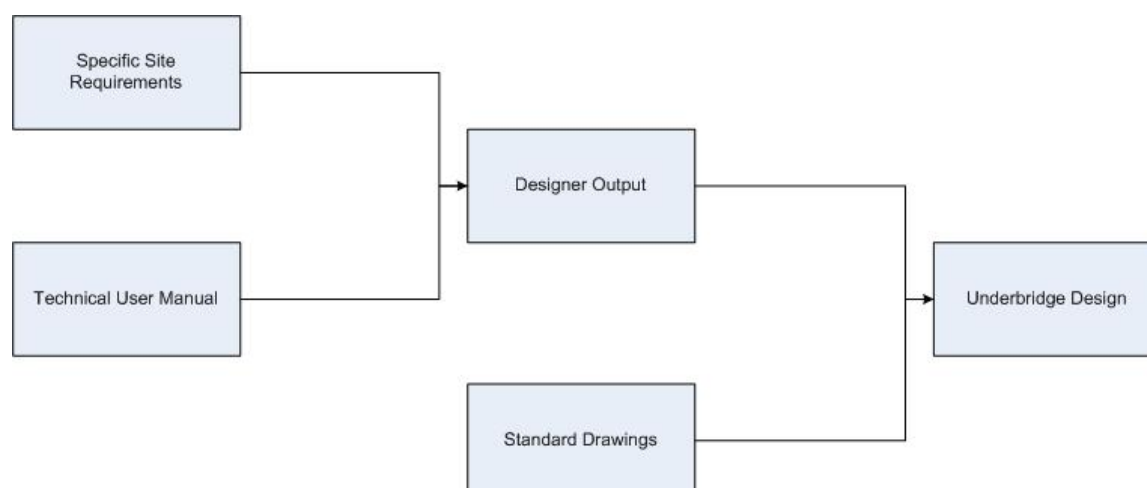


Figure 1: Flowchart to show the use of Network Rail's Standard Details and Designs

This manual describes the 2009 standard for rail underbridges using a half through construction arrangement of E-type main girders with either a filler beam floor, composite floor or a steel floor. It is intended to be read in conjunction with the set of standard drawings listed in Appendix A and aid the designer in producing an individual bridge design

using this standard, or in comparing these standard designs and details with other solutions. The manual discusses issues that will need to be covered in a contract specification for a bridge of this type.

The designer is required to determine the bridge steelwork layout and produce a scheme specific deck steelwork general arrangement drawing. The designer will also have to produce survey, proposed general arrangement, substructure detail, track layout and levels and setting out drawings, as necessary, plus detailed reinforced concrete drawings and schedules. As the E-type standard designs and details have been developed to a medium level of standardisation, the designer is also required to design and produce drawings of the main girder details. A list of the standard drawings used that define the required works shall be included on the general arrangement drawing.

The standard drawings shall not be redrawn or modified. Any required changes (e.g. when defining geometry or facilitating construction methodology) shall be shown on a separate drawing that clearly identifies the affected details.

The floor and other components have been designed to cater for a wide range of spans, skews and track geometry. For situations outside these parameters, the standard cannot be assumed to be applicable. Equally it will be obvious that the design here, in catering for such a wide range of circumstances, will inevitably involve conservatism on specific aspects and for specific bridge arrangements. Thus it may be possible to use the existing design in whole or part outside the given limits without modification, or to achieve a less substantial design (e.g. lower weight) within those limits, but again in both cases they will need approval, full re-design, and an appropriate check. These are matters that will need discussion with Network Rail's project sponsor and Network Rail's professional head of civil engineering if such a course of action is favoured.

2.1 Approval of Schemes Using Standard Designs & Details

The SDDs for each half through underbridge form have been submitted and approved by Network Rail at both Form A and Form B (including a Category III Check) stages of the Network Rail approvals process in accordance with NR/CIV/SP/003 Issue 2. The flowchart in Figure 2 demonstrates the general process of using the SDDs and TUMs. The blue shaded boxes assist the designer to select the appropriate details or confirm the suitable options available. A list of typical site parameters to consider in determining the appropriate details or confirm the suitable options available is included in section 4.12.

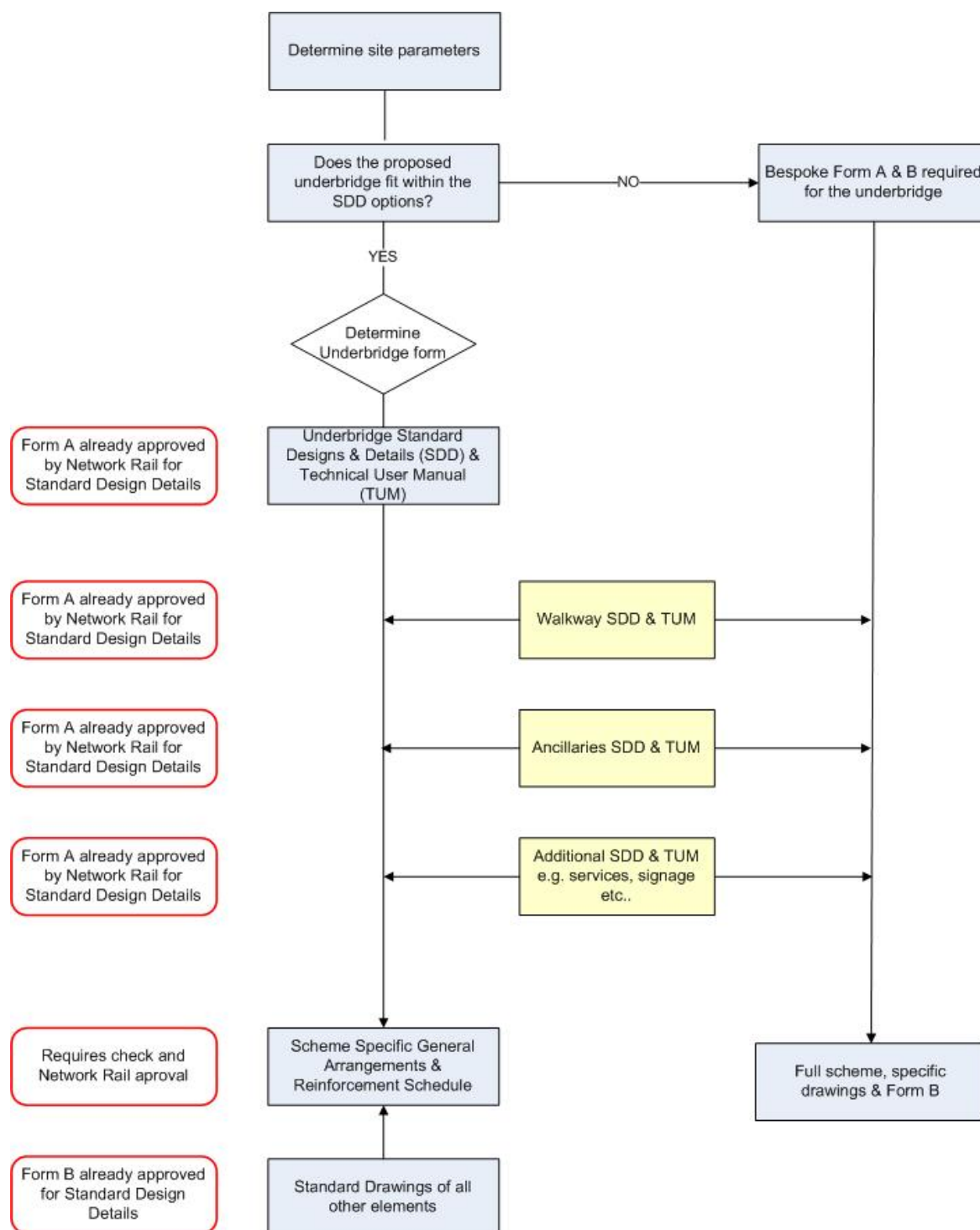


Figure 2: Process using the Standard Drawings and Technical User Manuals

The designer will need to produce a scheme specific Form A for the site under consideration. This Form A will detail the site specific parameters, include a gauging diagram and a list of the SDDs that will be used. As discussed previously the SDD Form As have been approved and a site specific Form A is to be produced to gain approval for use of the particular SDDs selected on the scheme.

Following Form A approval the designer will only need to produce general arrangement drawings, drawings of elements not developed to a high level of standardisation, e.g. main girders, and reinforcement schedules for the scheme. As discussed previously the SDDs have been approved (Form B), and include a Category III Check. Therefore the checking required for each specific scheme will be of the general arrangement, drawings of elements not developed to a high level of standardisation and reinforcement details and schedules to ensure they are suitable in meeting the scheme requirements.

The level of checking required is:

- Category I Check of the application of the standard designs and details
- Category II Check of the general arrangement (including site survey information) and bar bending schedules
- Category II Check of details not developed to a high level of standardisation

2.2 Modifications to Standard Designs & Details

Modifying the standard designs and details will only be accepted by Network Rail where the modifications can be justified technically and where it can be demonstrated that the modifications will not incur any significant additional whole life cost to Network Rail. Any modification invalidates the Standard Designs and Details Form As and Form Bs. In the event that modification is proposed the following justification must be provided:

- Technical justification considering structural capacity, longevity with respect to fatigue and reserves for future corrosion allowance:
 - Form A documentation.
 - Form B documentation.
- Cost justification
 - Estimate of the increased cost of maintaining non-standard assets.
 - Estimate of the increased cost of managing non-standard assets.
 - Estimate of the increased cost of additional Network Rail approval and review costs.

3 E-TYPE UNDERBRIDGE APPLICATION DETAILS

The standard E-type design may be used at any suitable location in UK and complies with The Railways (Interoperability)(Amendment) Regulations 2007 (S.I No. 3386).

The standard drawings provide a complete set of details for the superstructure floor, bearing schedules and preferred details for elements not developed to a high level of standardisation. For a particular bridge, the designer needs to determine the specific layout, choose the appropriate floor drawings, add the necessary dimensions and exercise specific options on these standard drawings. The designer will also have to determine non-standard items and select suitable bearings. Section 3.1 identifies the items that have been developed to a high level of standardisation (i.e. do not require further, numerical design) and those items that require site specific design.

It is intended that only those standard drawings relevant to the specific contract are issued to the contractor as part of the contract drawings, together with general arrangement drawings for particular to the specific bridge and drawings of details not developed to a high level of standardisation. The general arrangement drawings prepared by the designer will specify all principal dimensions and sizes, including material grades. Standard drawings relevant to the particular bridge should be listed on the general arrangement drawing.

The standard drawings allow for skew spans between 12m and 30m for three skew related ranges:

- Square spans.
- Spans for bridge skews in the range 0° to 25° .
- Spans for bridge skews in the range 25° to 50° .

Where skew affects the design details (e.g. cross girder / transverse rib details), there are three separate standard drawings, one for each range. For other details which are not skew related, there is a single drawing.

The designer should therefore choose the relevant drawings for his particular bridge skew range from the full set of standard drawings. Refer to flowchart in Figure 4.

For skew bridges, the drawings are drawn for one (unstated) particular skew and span, which may not match the particular bridge under design. The standard design has considered all skew variations and the details shown can be rotated to suit the required skew.

For the overall layout of the superstructure the key drawings are:

- The steelwork general assembly (for the relevant skew range).

- The filler beam, composite or steel floor dimensional details (for the relevant skew range).

The standard drawings were not developed to be used as fabrication drawings and fabricators may have to produce accurate bridge specific drawings. Most views will therefore need adjustment to the exact dimensions chosen for the particular bridge. Note that the standard drawings shall not be redrawn or modified and the required changes shall be shown on separate drawings.

3.1 Check List of Standard and Non-Standard Items

Such is the range of possible E-type decks applications, the E-types were developed to a medium level of standardisation, i.e. certain items including the floors could be efficiently designed and detailed whereas other items, such as the main girders, would be more efficiently designed to suit specific site constraints. Details not developed to a high level of standardisation are shown as broken lines on the SDD drawings.

The check list (not exhaustive) in Figure 3 lists the standard and non-standard items, design responsibilities and notes. This list is replicated on drawing NR/CIV/SD/1504.

'E' TYPE UNDERBRIDGE STANDARD DETAILS – DESIGN RESPONSIBILITIES			
ELEMENT		STANDARD DETAIL OR DESIGNER TO DETERMINE	NOTES
GENERAL ARRANGEMENT	DECK SKEW	DESIGNER	SITE SPECIFIC
	TRIMMER SKEW	DESIGNER	SITE SPECIFIC
	SPAN	DESIGNER	SITE SPECIFIC
	OVERHANG (DECK FROM MAIN BEARINGS)	DESIGNER	DESIGNER TO MINIMISE AND ENSURE VERTICAL MOVEMENT WITHIN LIMITS STATED IN STANDARDS LISTED
	ARTICULATION	STANDARD	REFER TO TECHNICAL USER MANUAL
MAIN GIRDERS	FLANGES	DESIGNER	MINIMUM FLANGE THICKNESS TO BE 30mm
	WEB	DESIGNER	MINIMUM WEB THICKNESS TO BE 20mm
	DOUBLER PLATES	DESIGNER	–
	SHEAR STUDS	DESIGNER	IF REQUIRED FOR LONGITUDINAL SHEAR
	BEARING STIFFENERS	DESIGNER	TYPICAL ARRANGEMENT AND DIMENSIONS PROVIDED
	INTERMEDIATE STIFFENERS	DESIGNER	TYPICAL ARRANGEMENT AND DIMENSIONS PROVIDED. CROSS GIRDER / TRANSVERSE RIB CONNECTION CALCULATED ON ASSUMED MAIN GIRDER SIZES.
BEARINGS	BEARING PLATE (TRIMMER AND MAIN GIRDER) ARRANGEMENT	STANDARD	DESIGNER TO CONFIRM BEARING DIMENSIONS AND PROVIDE FIXING ARRANGEMENT SHOWN ON DRAWINGS
	UPLIFT RESTRAINT	STANDARD	DESIGNER TO CONFIRM WHETHER REQUIRED, POSITION AND DIMENSIONS
	MAIN GIRDER BEARINGS – SPHERICAL	DESIGNER	BEARING SCHEDULE PROVIDED
	MAIN GIRDER BEARINGS – ROCKER	DESIGNER	BEARING SCHEDULE PROVIDED
	TRIMMER GIRDER BEARINGS	DESIGNER	BEARING SCHEDULE PROVIDED
FLOOR	TRIMMER	STANDARD	DESIGNER TO CONFIRM LENGTH
	TRIMMER END PLATE	STANDARD	–
	CROSS GIRDER AT U FRAME	STANDARD	DESIGNER TO CONFIRM LENGTH (AFTER MACHINING)
	CROSS GIRDER NOT AT U FRAME	STANDARD	DESIGNER TO CONFIRM LENGTH (AFTER MACHINING)
	CROSS GIRDER TO MAIN GIRDER CONNECTION AT U FRAME	STANDARD	DESIGNER TO CONFIRM STANDARD DETAIL APPROPRIATE FOR MAIN GIRDER AND CROSS MEMBER ARRANGEMENT AND LONGITUDINAL SHEAR EFFECTS
	CROSS GIRDER TO MAIN GIRDER CONNECTION NOT AT U FRAME	STANDARD	DESIGNER TO CONFIRM STANDARD DETAIL APPROPRIATE FOR MAIN GIRDER AND CROSS MEMBER ARRANGEMENT AND LONGITUDINAL SHEAR EFFECTS
	TRANSVERSE RIB AT U FRAME	STANDARD	DESIGNER TO CONFIRM LENGTH (AFTER MACHINING)
	TRANSVERSE RIB NOT AT A U FRAME	STANDARD	DESIGNER TO CONFIRM LENGTH (AFTER MACHINING)
	TRANSVERSE RIB TO MAIN GIRDER CONNECTION AT U FRAME	STANDARD	DESIGNER TO CONFIRM STANDARD DETAIL APPROPRIATE FOR MAIN GIRDER AND CROSS MEMBER ARRANGEMENT AND LONGITUDINAL SHEAR EFFECTS
	TRANSVERSE RIB TO MAIN GIRDER CONNECTION NOT AT U FRAME	STANDARD	DESIGNER TO CONFIRM STANDARD DETAIL APPROPRIATE FOR MAIN GIRDER AND CROSS MEMBER ARRANGEMENT AND LONGITUDINAL SHEAR EFFECTS
	CONCRETE OUTLINE	STANDARD	DESIGNER TO CONFIRM OUTLINE
	REINFORCEMENT	STANDARD	DESIGNER TO PROVIDE BAR BENDING SCHEDULES
PROTECTIVE TREATMENT		STANDARD	–
WATERPROOFING		STANDARD	REFER TO STANDARD ANCILLARIES DRAWINGS SERIES NR/CIV/SD/1800
WALKWAYS		STANDARD	DESIGNER TO CONFIRM WHETHER REQUIRED AND REFER TO STANDARD WALKWAY DRAWINGS SERIES NR/CIV/SD/1900
LIFTING ARRANGEMENTS		DESIGNER	STANDARD LIFTING BRACKET DETAILS ON DRAWING SERIES NR/CIV/SD/1800

Figure 3: List of Standard and Non-Standard Items, Design Responsibilities and Notes

3.2 Drawing Selection Flowchart

The following flowchart assists the designer in deciding the options to select and which drawings to use in detailing an E-type deck:

Copyright Network Rail
Provided by IHS under license with Network Rail
No reproduction or networking permitted without license from IHS

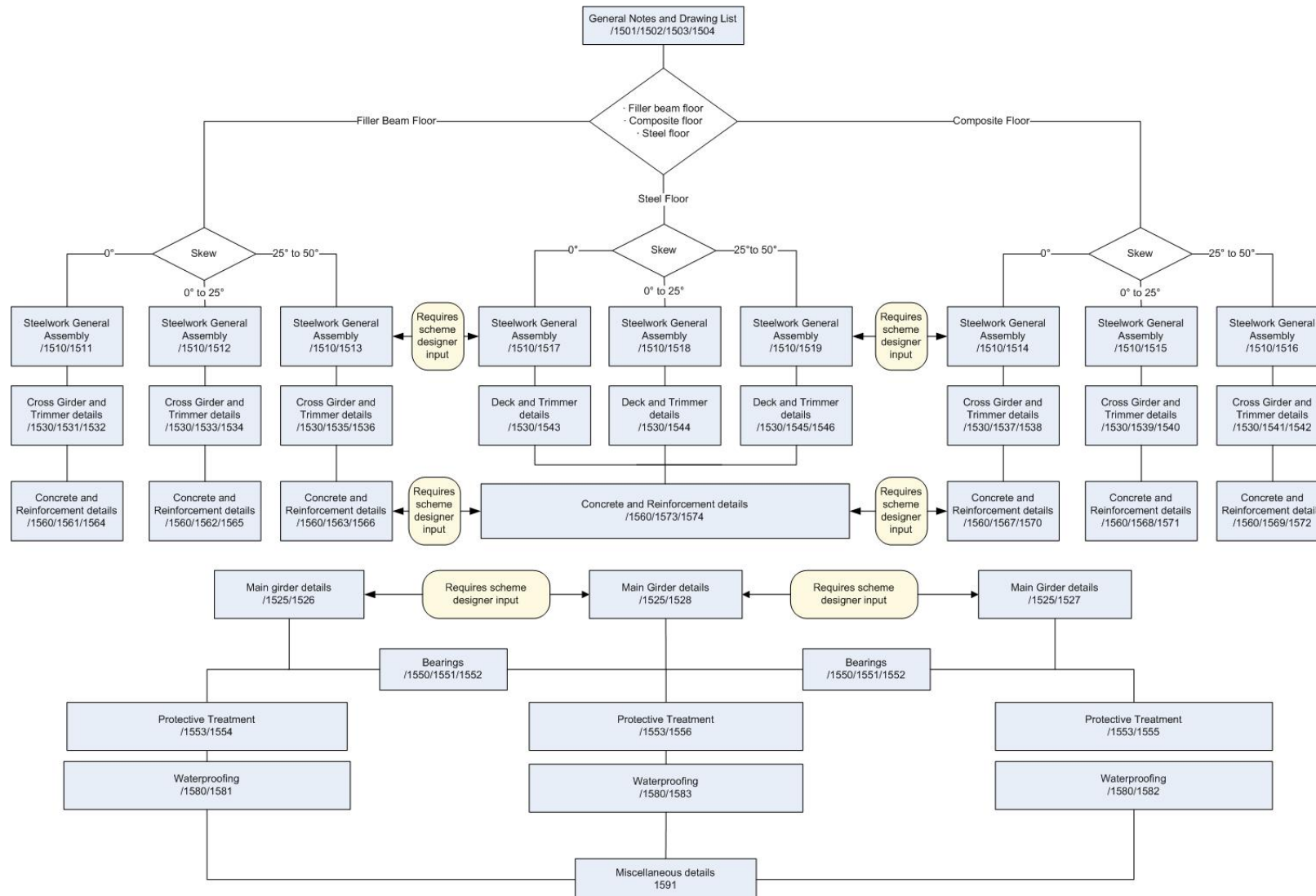


Figure 4: Process to determine the Standard Details and Designs to use in detailing a Standard E-type Underbridge

4 DETAILS OF STRUCTURAL FORM

The standard E-type deck comprises a double track half-through deck with two I-shaped steel main girders and either a filler beam, composite or a steel floor. The main girders will be positioned within the platform gauge and simply supported on either line rocker bearings or spherical bearings (at obtuse corners of 25° to 50° skew decks). Trimmer girders are supported on the inside edge of the main girder bottom flanges for skews up to 25°, and spherical bearings for all skews from 25° to 50°. Refer to the figures in Appendix D for general arrangement details.

In all cases, it has been assumed that the E-type deck will be constructed offline and lifted, slid, jacked or moved into its final position using self propelled lifting vehicles (SPLV). Alternative installation options, including lifting with rail mounted or mobile cranes, may be appropriate and should be agreed with the project sponsor with reference made to the check list in section 5.

4.1 Geometry and Configuration

The designer will need to utilise the following Railway Group Standards (or their successors, where appropriate):

- GE/RT8073 – Requirements for the Application of Standard Vehicle Gauges.
- GC/RT5112 – Loading Requirements for the Design of Bridges.
- GC/RT5203 – Infrastructure Requirements for Personal Safety in Respect of Clearance and Access.
- GC/RT5212 – Requirements for Defining and Maintaining Clearances.
- GE/GN8573 – Guidance on Gauging
- NR/L2/CIV/020 – Design of Bridges and Culverts (a copy of draft 12 appended to this TUM)
- GC/RC5510 – Recommendations for the Design of Bridges.

4.2 Span

The span range of the standard E-type underbridges considered in the SDD is the span measured between centres of bearings and is 12.0m to 30.0m. Although not considered in SDD, the floor details given on SDD, may be applicable for longer spans. The approval process in this case is as described in section 2.2. Note that careful consideration of the girder size and location of the cess walkway is required to ensure direct access to a continuous position of safety is achieved where reasonably practicable.

4.3 Skew

The skew range, measured between the bearing centre line and perpendicular to the track centreline, is 0° (square) to 50° (maximum).

4.4 Floor Type

There are three E-type floor arrangements; a filler beam floor option, a composite floor option, and a steel floor option. The filler beam floor is Network Rail's preferred option and is suitable for the majority of schemes with the exception where available construction depth is limited or where lifting weights or the loads on existing abutments are to be minimised. In this situation, the steel floor option is advantageous. The composite floor option is lighter than the filler option with fewer hidden parts, but its deeper construction depth may limit its use to new build situations.

The composite and steel floor standard detail includes a maintenance gap between the transverse rib flange and main girder flange. This gap must not be reduced without the agreement with Network Rail's professional head of civil engineering. There are further advantages of using the filler beam floor, including less long term maintenance and a lower capital cost. As such the filler beam floor is the preferred option.

4.5 Floor Width

The E-type floors have been developed up to 9600mm wide to allow flexibility in using the design: With straight track, a cess walkway may be located on the floor (suitable for longer span situations where direct access to a position of safety is not possible) or the floor can accommodate curved track (noting that track cants will be limited (section 4.9) to ensure the ballast depth is within the limits specified in section 4.10).

Floor widths and the position of any cess walkways will also be affected by the cant, curvature and track alignment of each particular bridge location and also the geometry (flange width) of the none SDDs main girders. The designer must ensure a suitable floor width is chosen and main girder designed to suit the site specific requirements while addressing these issues and ensuring suitable installation and future track slue tolerances.

Consideration must also be given to existing abutment width and adjacent structures, walkway positions and bridge end access requirements. Typical minimum track radii, excluding cant effects and assuming 3400mm between track centres, that can be accommodated by the standard designs and details are given indicatively in Table 3.1. The designer is responsible for confirming scheme specific details:

Floor width	7005mm	9485mm	9600mm		7005mm	9600mm	9600mm
Span	12m	12m	12m		30m	30m	30m
Speed	200kph	200kph	40kph	160kph	200kph	160kph	160kph
Radii	∞	∞	200m	1260m	∞	∞	1500m
Comment	Absolute minimum width	Minimum width, cess walkway on floor	Maximum width, cess walkway off floor	Maximum width, cess walkway off floor	Absolute minimum width	Minimum width, cess walkway on floor	Maximum width, cess walkway off floor

Table 3.1 Indicative Minimum Track Radii on a Standard E -Type Deck

4.6 Construction Depth

The construction depth for each E-type floor type varies with span ranges and ballast depth, with a minimum of 1123mm and a maximum of 1383mm (not including allowance for main girder bottom flange plate thickness or doubler plates). Refer to drawings NR/CIV/SD/1501 to 1503 for specific details. The construction depth has been determined assuming the following: depth of track (rail, rail pads and sleeper) of 368mm, the nominal ballast depth, waterproofing (assumed as 15mm thick) and the chosen floor type depth.

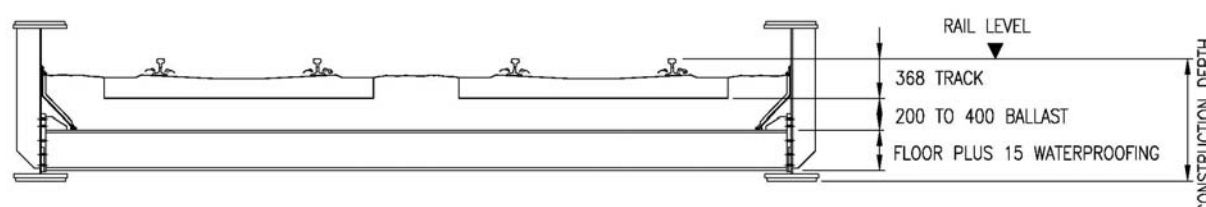


Figure 5: Construction Depth

4.7 Clearances

4.7.1 Structure Gauge Clearances

The designer should:

- Ensure that adequate clearance is provided between existing and proposed vehicles and the structure.
- Consider the maximum offset of the rail centre line and bridge centre line.
- Ensure that the structure gauge considered (to include cant and end throw allowances) is suitable for the line considered for each specific scheme, in accordance with current Network Rail and Railway Group Standards.
- Ensure that the required track radius (if any) will not result in encroachment on the structure gauge by any part of the deck or walkway.

4.7.2 Static Electrical Clearances

Where conductor rails are present, the designer should:

- Ensure that adequate clearance is provided between the conductor rail and the structure

4.7.3 Clearance Limits Affecting Design.

It is assumed that a single E-type deck will be provided. Where the number of tracks exceeds two, it is assumed that E-type decks are used only where wide ten foot exists. Otherwise individual half through standard deck types such as Z-types and U-types will be used.

Where an E-type is used, it is assumed that the main girder top flange will act as a robust kerb, i.e. the top flange will be greater than 300mm above rail level and within the platform gauge. The designer must check the clearance from the compression flange inside edge to the kinematic envelope, noting that where the distance from rail level to top of top flange exceeds 915mm, the lateral clearance from the near rail must be increased from 760mm to 1030mm. An absolute minimum clearance of 32.5mm between the lower sector structure gauge and the main girder has been assumed. Note that the designer should assess if this is acceptable for specific bridges, i.e. permanent way clearances and requirement to maintain gauge, or construction and installation tolerances, as a minimum clearance of 50mm is desired for possible future works.

The sleeper end positions will not be critical for E-type decks. Where cess walkways are not located on the floor, their position and width must be carefully determined to clear the upper part of the kinematic envelope with particular attention paid to canted or curved track arrangements.

If a pair of E-type decks are located adjacent to each other, the designer must also confirm the girders can be located within the space available in the ten foot. Typically there will be insufficient space in the ten foot for a pair of E-type girders and an alternative deck type arrangement will have to be provided.

4.8 Track Arrangement

An absolute minimum clearance of 32.5mm between the lower sector structure gauge and the main girder has been assumed although it is recommended that where possible, a minimum clearance of 50mm should be provided for possible future track slues.

The total lateral tolerance for track and deck installation relative to the centre line of the deck assuming straight track, main girder dimensions as stated on drawing NR/CIV/SD/1504, is $\pm 1347.5\text{mm}$ on a 9600mm wide deck with the cess walkway not on the floor, reducing linearly to $\pm 32.5\text{mm}$ on a 9600mm wide floor with the cess walkway on the floor and line speed exceeding 125mph / 200kph. Note that the maximum tolerance dimension limited to 175mm on drawings NR/CIV/SD/1501 to 1503.

The designer should check that the effects of curved track (end and centre throws) does not cause the structure gauge to foul the structure or compromise the clearance to the cess walkway and that sufficient installation tolerances are provided.

4.9 Cant and Deck Super Elevation

The absolute maximum cant permitted on the standard design is 150mm, relative to the rails. This is made up of track cant and deck super elevation. The designer should ensure that the effects of cant, such as cant throw do not cause the structural gauge to foul the structure. The limits of the cant components can be seen in Figure 6.

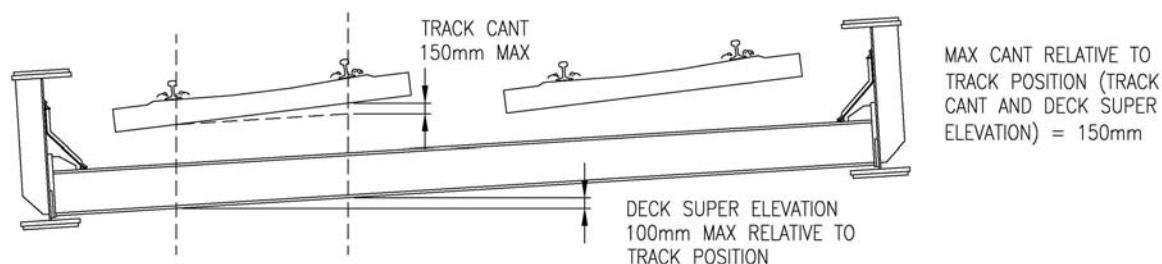


Figure 6: Cant Effects

To ensure that the maximum ballast depths on the floor do not exceed the allowable (refer to section 4.10) and to minimise the construction depth, track cants may differ or the tracks be at different vertical positions as shown schematically in Figure 6.

4.10 Ballast Depth

The desired ballast depth is 300mm at mid span under the low rail. Shallower ballast depths may be used, to a minimum of 200mm, however permanent way approval will be required. The absolute maximum ballast depth below the sleeper shall be 400mm averaged over the span.

4.11 Sleeper and Rail Details

The total depth of the rail, chair and sleeper has been taken as 368mm.

4.12 Site Constraints

The designer will need to consider the site constraints, including but not limited to: OLE, existing abutments, S&T, location of cess, access, installation methodology etc. Headroom above highways or waterways should be maximised where possible and appropriate signage fixed to the structure (ideally to the bash beam or web stiffener. Refer to ancillary details in NR/CIV/SD/1800 series). Note that the signs will be the responsibility of the Local Authority, Highways Agency or similar authority.

4.13 Direct Fastening Systems

The standard E-type floor design has not been developed specifically to accommodate direct fastening systems but the use of the standard drawings does not limit their use to ballasted track. Where a direct fastening system is required for a specific scheme, the designer shall select the suitable standard design with the required track / structure performance. Additional design checks will be required to ensure suitability of the chosen detail as the intensity of the railway loads will be greater than for ballasted track. Form A and Form B submission and approval will be required.

5 INSTALLATION GUIDANCE

It has been assumed that the standard E-type deck will be either constructed in situ or constructed offline and lifted, slid, jacked or transported into its final position using self propelled lifting vehicles (SPLV). Alternative installation options, including lifting with rail mounted or mobile cranes, may be appropriate.

Where possible, to minimise railway possession times, the designer should consider installing the deck with bottom ballast in place, though the designer should ensure it's stability and that the ballast is suitably retained.

The details of the installation method proposed should be agreed with the project sponsor and the design checked (Form C) for the installation stages as appropriate.

5.1 Trial Erection

As stated on drawing NR/CIV/SD/1504 the bridge should be fully trial erected: The trial erection should include all superstructure and ancillary items such as walkways, impost / cill beams, ballast walls and cover plates. This is particularly important for skew bridges. During the trial erection all bolts should be hand tightened. Any HR bolts fully torqued should be marked and discarded.

5.2 Installation Tolerances

The designer must allow suitable tolerances for the installation method of the decks. The standard designs were developed assuming the decks could be installed by SPLV and be positioned within 25mm and the track placed within 15mm of the design position on plan. Vertical positioning tolerance of 10mm has been considered appropriate as it is assumed the track profile could be locally adjusted on site if necessary. Installation by alternative methods will require these tolerances to be reviewed.

5.3 Installation Guidance

Specific calculations will be required of the designer for the installation method proposed to ensure the capacity of the structure is not compromised at either the serviceability or ultimate limit state.

5.3.1 Installation Using SPLV

Where the decks are installed by SPLV the designer should ensure that support positions under one girder are located perpendicularly opposite to the support positions under the opposite girder. Ideally support positions should be located at the web stiffener locations. Where the web stiffener arrangement is such that web stiffeners are not perpendicularly opposite, an additional web stiffener may be required in the appropriate location.

The support positions or lifting points should ideally be located between the quarter and third points of the span and the designer must ensure that during installation, the stresses (a safety factor of 2.0 is recommended) in the main girder do not exceed the theoretical stresses at the end of installation from permanent loads, unless specific stress checks are undertaken.

5.3.2 Installation Using Cranes

Where the decks (complete or otherwise) are installed by lifting them using lifting brackets attached to the main girder top flanges, the designer should ensure that lifting points on one girder are located perpendicularly opposite to the lifting points on the opposite girder. Lifting brackets should be located at the web stiffener locations. Where the web stiffener arrangement is such that web stiffeners are not perpendicularly opposite, an additional lifting web stiffener may be required in the appropriate location. Care must be taken when determining the curtailment of any top flange doubler plates to ensure any lifting bracket is in full contact with the flange doubler plate.

The lifting points should ideally be located between the quarter and third points of the span and the lift arrangement should ensure no transverse force is applied to the main girder top flange, unless a suitable temporary bracing system has been installed for the lift. In all cases the designer must ensure that during the lift, the stresses (a safety factor of 2.0 is recommended) in the main girder do not exceed the theoretical stresses at the end of installation from permanent loads, unless specific stress checks are undertaken.

5.4 Check List for Installation Options

The following check list (not exhaustive) lists checks to be undertaken and items to be designed or checked by the designer for the scheme specific installation option. Where appropriate, a separate Form C will be required.

- The effect of the proposed lifting / support arrangement on;
 - o the lifting lugs (where applicable),
 - o the load distribution to each lifting / support point,

- o the effect on the main girder. Twist during installation or fabrication shall be minimised. No one bearing shall move more than span/500 vertically compared to the plane of the other three bearings.
 - o the effect on the floor: Twist or sag during installation or fabrication of steel floor panels shall be minimised to ensure the floor plate stresses remain elastic. In calculating the stresses for the particular panel and lifting arrangement, a safety factor of 2.0 is recommended.
- The suitability of the substructure:
 - o check the load effects from the new deck including pressure at base and under the impost / cill beam,
 - o check overturning and sliding stability with and without the new deck in place.
- Undertake suitable geotechnical investigation to determine soil properties.
- Check that the differential settlement predicted does not exceed the value the standard designs have been designed to accommodate (At SLS, 1 in 1000 along the abutment subject to a maximum 5mm difference between bearings).
- Check installation tolerances noting that methods of installation other than by crane may be more suited for installation in short (8 hour) possessions but may require additional installation tolerances (refer to section 5.2).

The following check list (not exhaustive) lists typical issues to be considered by the designer for the particular scheme when deciding on the available options to install the deck.

- Access to site
 - o Clearances to street furniture, overhead cables, low headroom or weight restricted bridges etc.,
 - o Road profile (horizontal and vertical): Proximity to hump back bridges, tight curves etc. that may restrict access to site or plant movement.
 - o Location for site compound.
- Services: Highway / waterway.
 - o Services in or alongside the highway or waterway must be protected from bridge installation activities.
- Services: Railway.
 - o Services may restrict or complicate installation of new bridge decks. Some methods of installation will be more suited for sites with numerous railway services, e.g. if services cannot be raised, this may preclude installation with SPLV.
- Access around site
 - o Consider size of compound to construct the deck off line, rig cranes, store plant and materials, store bridge elements, staff accommodation and welfare provision.
- Site properties
 - o Strength of ground (ground reinforcement or piling for cranes or temporary works),
 - o Access to site (haul roads and access agreements with land owner),

- o Environmental issues (minimise damage to habitat, restrictions due to the presence of rare or protected fauna and flora, relocation of rare or protected fauna and flora, limitations on time of year to do the work to minimise impact on flora and fauna).
 - o Working over water.
- Available possessions
 - o Minimise all possession times.
 - o Railway possessions. Strive for an 8 hour railway possession. Installation with SPLV is usually quicker, thus minimising railway possessions, but will need larger installation tolerances and will not be suitable for all sites.
 - o Highway and waterway possessions may be limited at certain times of the year, depending on the site location, e.g. a highway possession will be unlikely in December if the site adjacent to a retail outlet, and a waterway possession unlikely in July and August if heavily trafficked with recreational vessels.

6 GUIDANCE FOR USE OF THE E-TYPE STANDARD DESIGNS AND DETAILS

6.1 General Arrangement Drawing

General arrangement drawings should be produced in line with Network Rail's requirements for the specific site. However it is expected that these drawings should normally include the following:

- Plan, bridge elevation and a cross-section through the bridge including the elevation of one abutment and the bridge seating arrangement.
- Geotechnical information, details of services (railway and other), details of land ownership and details of adjacent infrastructure,
- Principal dimension information such as span, skew, clearances from rail to main girders and walkway parapets, six foot gap (where applicable), bearing, bridge soffit, rail, walkway and parapet levels, clearance to road (or river or rail as applicable).
- List of drawings forming the complete bridge design.
- Scheme specific deck steelwork general arrangement drawing.

6.2 General Assembly Drawings

The setting out and arrangement of cross girders / transverse ribs, trimmers and main girders will be unique in most instances and dependent upon many variables including, bridge span, abutment skew, clearance requirements, main girder stiffener design and compliance with minimum and maximum spacing requirements of cross girders.

Where decks are to be positioned side by side, the designer should ensure web stiffener positions are staggered to enable future access for inspection and maintenance.

It should be noted that the trimmer skew will be different to the bridge (abutment) skew where the bridge skew is between 0° and 25° , as the trimmer is supported inboard on the main girder bottom flanges. The floor overhangs the trimmer and for lower skews, the floor skew may equal the deck skew. Note that for all skews (0° to 50°) the overhang should be minimised to reduce torsional effects on the trimmer and the designer should consider the floor skew not equalling the bridge skew, and make up the difference in the ancillary details.

For setting out of the trimmer refer to drawings NR/CIV/SD/1534, 1536, 1540, 1542, 1545, 1546 and Figure 7.

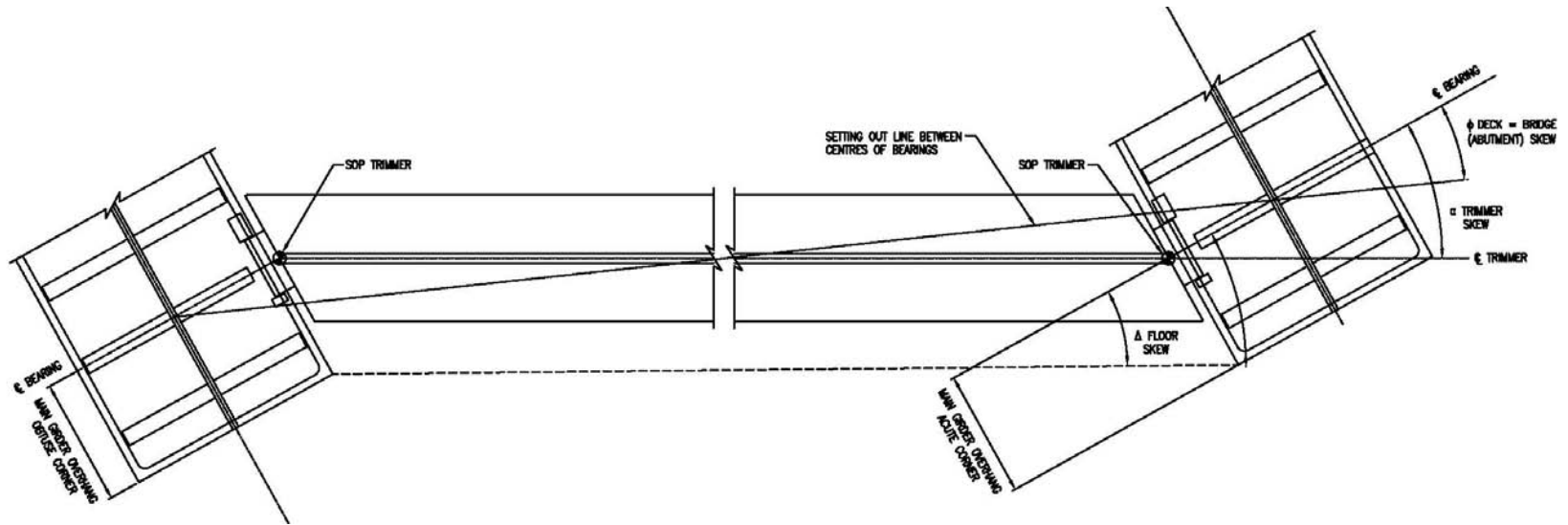


Figure 7: Definition of Skews

General Arrangement of Cross Girders or Transverse Ribs

The general arrangement drawings give the applicable range of gross girders or transverse ribs spacing. Where possible, the designer should maximise the spacing to facilitate access for fabrication, and in the case of filler beam floors, simplify the concrete soffit. The closer spacing allowed should generally be used only when the cross girders or transverse ribs are fanned.

Where close centre cross girders are unavoidable on filler beam floors, the designer should consider detailing a flat concrete soffit and providing additional reinforcement as necessary.

Bridge skew up to and including 25°

For bridge skews up to and including 25° skew, a fanned cross girder or transverse rib arrangement is required at the deck ends as acute connections into the trimmer are neither desirable nor practical. Fanning of the last few cross girders is usually all that is necessary on low skew bridges. As the skew and deck width increases, the required number of fanned cross girders / transverse ribs increase and fabrication details may become excessively complicated. In these instances there is an option to skew the cross girders / transverse ribs by the same amount through the bridge to allow duplication of fabrication details.

For shorter spans or wide decks, fanned cross girders / transverse ribs are not practicable, as there is insufficient length available to fan the cross girders / transverse ribs perpendicular to the main girder. For these cases cross girders / transverse ribs should remain parallel to the trimmer girder. For details refer to standard drawings NR/CIV/SD/1501 to 1503.

Where a filler beam floor is required, fanned cross girders will complicate the concrete profile. To simplify details of the concrete profile / deck soffit it is recommended that for skews less than 25° all cross girders are parallel, i.e. skew. Should the designer prefer to fan the cross girders, e.g. for narrow decks and low skew angles typically <10°, although not specifically drawn on the standard drawings, the SDD has considered this case and fanned cross girders do not represent a modification to the SDD.

Bridge skews between 25° and 50°

For bridge skews between 25° and 50° a trimmed cross girder / transverse rib arrangement is shown at the deck end. All cross girders / transverse ribs are square to main girders. Where cross girders / transverse ribs connect into the trimmer, there are alternative details for the filler beam, composite and steel floor types.

Setting out of the cross girders / transverse ribs shown on the standard drawings considers the setting out point as the intersection at the main girder web and a line perpendicular to the web at the point the cross girder / transverse rib centre line meets the inside of the web. Where

required, the centreline at the web stiffener goes through the setting out point. Refer to Figure 8.

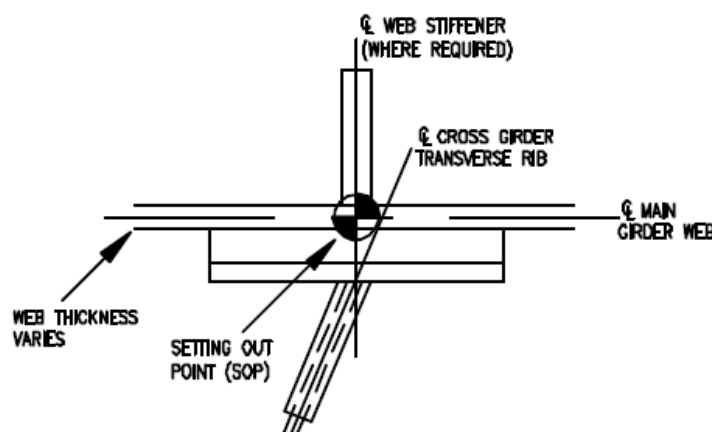


Figure 8: Cross Girder / Transverse Rib Setting Out

6.3 Additional Consideration for Steel Floors

Steel floors will require the floor plate to be spliced as it is unlikely that the floor plate can be fabricated and installed as a single floor panel. Floor plate splices may be bolted or butt welded.

Details of the splice are given on the steel floor transverse rib details drawings. The designer should position the splice to suit the transverse rib spacing required, ensuring that adequate space is provided to tighten up the bolts or weld. To facilitate easier site access, the designer may consider off setting the splice towards one transverse rib.

Where the bridge skew exceeds 25° and trimmed transverse ribs are required, the floor plate splice must be carefully located to ensure it is clear of the main girder and trimmer girder bearing area. The edges of the floor plate required (site) welding to the trimmer girder.

6.4 Details Drawings

Details are provided for a range of deck widths and skews. For steel floors, to avoid any conservative designs, the details depend also on the traffic type and annual tonnage. This section gives guidance on how the required details should be selected.

6.4.1 Skew

The standard details and drawings give details for particular skew ranges. Where a skew of 17.4° , the details for deck skews (i.e. between main girder bearings) between 0° and 25° are to be used. Where skews are 0° or 25° , the designer may choose the drawings to be used, but must

ensure they are used consistently. For very low skew angles, the designer should, where practicable, make the bridge square as this will simplify many of the details.

6.4.2 Traffic

The standard designs and drawings give details that may vary depending on the railway traffic anticipated at the particular site. Where details vary, e.g. steel floor deck plate thickness, the detail to be used is either classified HEAVY or LIGHT in the table given on the particular drawing and replicated below in Figure 9.

ANNUAL TONNAGE x10 ⁶	42-27	27-18	18-12	12-7
TRAFFIC				
25t axles	HEAVY GIRDERS			LIGHT GIRDERS
EC Mix				
Type 9 MUs				

Figure 9: Traffic Type and Detail Classification

E.g. for a detail subject to 15 million tonnes of traffic per annum and EC1 mix traffic type, the details to be used are the LIGHT details, as shown above.

Where the annual tonnage is stated in two columns, the column to the left shall be used, e.g. if the detail is subject to 18 million tonnes of traffic per annum and EC mix traffic type, the details to be used are the HEAVY details.

All other details have been designed to sustain 42 million tonnes of traffic per annum and 25t axle traffic type.

6.5 Main Girders

The design of the main girders is the responsibility of the designer. Preferred details, shown as broken lines, are given on the SDD drawings and where possible should be replicated in the design of the main girders. Where preferred details are not used, details should be provided at Form A stage as described in section 2.2.

The length of the main girder will be determined by the designer: To simplify the ancillary details and arrangements (e.g. ballast walls, impost / cill units, refer to series NR/CIV/SP/1800) the bridge skew will not equal the trimmer skew except for square decks and trimmed decks. The floor skew may be kept equal to the bridge skew by varying the floor overhang past the trimmer but the overhang should be minimised to reduce torsional effects on the trimmer. The

designer should consider the floor skew not equalling the bridge skew, and make up the difference in the ancillary details. Typical, maximum overhang dimensions are given as the standard drawings and these values should not be exceeded. The depth of deep main girders should be determined by the designer to suit the required ballast depth.

Approximate section sizes assumed in developing the floor details are provided on drawing NR/CIV/SD/1504. The main girders will be located in the platform gauge and the height of the top flange should not be less than 300mm above rail level so that the main girder may act as a robust kerb. Note that where a cess walkway is not located on the floor, where reasonably practicable the main girder height above top of sleeper level should not exceed 500mm to provide immediate access to a position of safety in accordance with NR/SP/OHS/069, and a non slip finish shall be provided on the flange. Where immediate access is not provided nor a cess walkway located on the floor, the designer shall provide adequate access to the position of safety in accordance with NR/SP/OHS/069.

The connection between the floor, i.e. cross girder / transverse rib to web details and concrete to web details, are discussed in Appendix and must be considered in the design on the main girders. Failure to provide suitable connection between the main girder and the floor may result in the floor capacity being compromised.

6.6 Bearings

Bearing schedules for the main girder and trimmer girder bearings where bridge skews exceed 25° are included for each floor type. Refer to drawings NR/CIV/SD/1550 to 1552. The schedules give the nominal reactions for each floor type for spans of 12m, 21m and 30m with interpolation required for other spans. The reactions have been calculated based on the assumptions given on the relevant drawings and are generally upper bound values. Where necessary, the designer may calculate more accurate bearing reactions. Careful selection of the bearings is required to ensure that the bearings provide the required girder end restraint (refer to Appendix C).

6.7 Concrete and Reinforcement Drawing

Reinforced concrete is required to act compositely with the steel cross girders in both a filler beam and composite floor. A reinforced concrete cantilever from the trimmer beam is required to achieve the required floor skew and support for ballast plates for the filler beam, composite and steel floors. The standard details provide a floor skew to match the bridge skew. This will generally ensure that the deck end is roughly parallel to the line of the abutment and also enables the possibility of aligning adjacent bridge decks with spans up to 25° skew.

The reinforced concrete standard drawings require tailoring to suit specific skew arrangements. In doing so the designs should maintain the size and spacing of the bars to ensure adequacy of

the reinforcement, and to ensure the minimum steel is present in any face to prevent early thermal cracking. Guidance is given on the standard drawings.

Floors should be detailed to allow easy placement of formwork and reinforcement as well as meeting all relevant design requirements.

Determining the dimensions of the floor and cantilever should be done with care and the following points taken into account:

- Reinforcement and cover to steelwork should be maintained.
- Adequate room should be provided around the trimmer for location of reinforcement and placing concrete.
- The floor end cantilever should be minimised and generally not increased above the typical values stated on the standard drawings as this will increase; loadings on the trimmer, loadings on the trimmer end restraints, floor overhang and inward moments on the bearings. It may also exceed the allowable upward deflection at the end of the deck.

The E-type filler beam and composite floors SDDs continue the floor concrete up the deck ends, around the inner bearing stiffeners. This detail will prevent debris collecting around the bearing stiffeners and is not structural. This concrete is not required for steel decks as ballast plates are provided and debris will not collect on their sloping faces.

As the majority of E-types will be single decks, maintenance and inspection access to the outer bearing stiffeners will be relatively straightforward and unlike the SDD Z-type and U-type, the bearing stiffeners have not been encased in concrete to prevent debris collecting. However, should a pair of E-types be installed side by side, encasing the bearing stiffeners in concrete should be considered.

6.8 Bar Bending Schedules

Production of deck specific bar bending schedules to accompany the deck drawings are necessary in all instances.

6.9 Protective Treatment and Waterproofing

6.9.1 Basic Principles and General Comments

The basic principles are as follows:

- All buried surfaces beneath or at the sides of the track are protected by a waterproofing arrangement designed to ensure water and other train related pollutants do not come into contact with the bridge superstructure and support / end units.

- Drainage arrangements, such as providing a longitudinal fall (recommended minimum fall 1 in 250, noting deck camber to be considered), are incorporated in the overall bridge design to minimise maintenance requirements.
- Other steel surfaces permanently exposed in the final structure are specified as receiving a protective treatment. Refer to standard drawings for details.

Both protective treatment and waterproofing should be carried out where possible in shop conditions to ensure the maximum integrity and quality. Details are shown on the standard drawings of the residual site joint protection involving hand applied protective treatment and waterproofing system. It is envisaged that some remedial site painting will be required, to be carried out in accordance with the Network Rail Specification.

6.9.2 Protective Treatment

The standard steelwork protective treatment specified is a type N1 system in accordance with NR/SP/CIV/039. The standard drawings show details in accordance with NR/GN/CIV/002. Where no guidance is provided the requirements of NR/GN/CIV/002 shall apply. Points to note are include:

- Areas encased in concrete (e.g. filler floor trimmer beams, filler beams) should remain untreated, only loose rust or mill scale removed.
- Areas partially encased in concrete (e.g. lower part of inner main girder, trimmer end blocks, steel floor trimmer beams, bearing stiffeners within concrete) should be blast cleaned and primed only.
- Where the concrete finishes the protective treatment for the adjacent area should be extended not less than 25mm into the concreted area and a sealant applied in a rebate in the concrete to minimise the risk of water ingress at the steel / concrete interface.
- Faying and bearing surfaces (e.g. bolted connections, trimmer support positions) are blast cleaned and metal sprayed only, to maintain optimum friction conditions with minimum protection. Subsequent layers of protective treatment to be stepped back.
- Joints carried out on site will need completion of protective treatment after bolting up or welding.
- Exposed areas inaccessible after erection are painted with the N1 system.
- Where concrete surfaces may be exposed to chlorides, e.g. filler floors above major highways and low headroom, applying a hydrophobic pore lining impregnant in accordance with Highways Agency Document BD43/03 should be considered.

The use of weathering steel was not developed as a standard design. Where the use of weathering steel has been assessed favourable, the standard designs and details may be considered as a basis for design but the design will be classed as a modification (refer to Section 2.2). Approval for the use of weathering steel is required from Network Rail's professional head of civil engineering. If weathering steel is to be used, the designer must (list not exhaustive):

- Follow requirements of Highways Agency standard BD7/01, including increasing the plate thicknesses.
- Check the bridge deflection are within the limits set in BS EN 1990:2002 and NR/L2/CIV/020.
- Check the availability of components, in particular nuts and bolts (generally supplied in imperial sizes) and may not be available in the sizes called up on the standard designs.

6.9.3 Waterproofing

The waterproofing system shown is based upon an acrylic spray system protected with a protective layer against local damage. The waterproofing details are shown on drawing NR/CIV/SD/1580 to 1583. Deck ends are waterproofed to ensure water drains from the deck to the back of deck drainage. Alternative waterproofing systems complying with NR/L3/CIV/041 may be provided as an alternative to the preferred detail shown with the agreement of the project sponsor.

6.10 Drainage

Positive drainage should be considered where possible. Details of drainage provision options are given on the standard drawings and details in the series NR/CIV/SD/1800. Generally, drainage locations and thus the profile of the back of the impost / cill unit may be governed by the abutment thickness. A narrow abutment invites a simple arrangement of deck end and upstand aligned vertically with the rear of the abutment. Ideally the drainage pipe should be located below the final top of the existing abutment. This should ensure that water will not permeate along the underside of the impost and then down the abutment face.

Where the existing abutment is much wider and the new deck stops short then providing drains in the impost at the deck end and below impost / cill to the rear of the abutment is often preferred even to the extent of terminating the waterproofing at the impost / cill drain.

6.11 Substructure and Ancillary Items

Within the standard detail suite of drawings, details are provided for underbridge ancillary items (drawing series NR/CIV/SD/1800 and associated technical user manual). The E-type superstructure details refer to these and the details regarding assumptions are contained therein.

To ensure a smooth transition from the stiffness of the bridge approach to the stiffness of the deck and then the stiffness of the deck to the stiffness of the approach, the designer should consider the use of a suitable transition detail.

Where an existing substructure is being reused the scheme design should ensure that there is no significant change in the loads or points of application, and also the acceptability to re-use of the existing substructure and foundations.

The design of the standard deck details covered in this TUM have assumed a maximum abutment differential settlement at SLS of 1 in 1000, but not exceeding 5mm under a single bearing. The load applied shall be in accordance with BS EN 1990:2002 and include railway loads. The designer shall determine the soil parameters and ensure that the maximum design settlement under a single bearing is not exceeded. Refer to the check list in Section 5.4 for guidance and limits on differential settlement allowed for in the standard designs.

6.12 Bonding / Stray Current / Insulation

The designer must ensure that suitable details are provided to ensure that the structure is adequately bonded / insulated / protected from stray current effects.

7 FABRICATION AND CONSTRUCTION

The standard details have been developed from previous E-type designs (refer to the history of the E-type development in Appendix B) and previous box girder standard designs (for the steel floor). The details are generally straightforward and a competent fabricator or contractor should be able to determine their own procedures for ensuring the required quality is achieved. The areas where the details require particular attention are discussed below.

7.1 Fabrication

The most difficult detail in the fabrication process is the machining and fitting of the cross girders / transverse ribs. It is intended that the end plates to the cross girders / transverse ribs are attached and then machined down to the exact thickness required for fit noting that the plate thicknesses shown on the standard drawings are the minimum thicknesses required at the end of machining. Alternatively the cross girders / transverse ribs could be machined to the correct length.

The fabricator must ensure that all faces are in full contact to make the HR bolted connections effective. This is particularly important for the shear key details on the steel floors where two separate faces must be in contact.

The fabricator must also pay due attention to the reinforcement location and orientation to ensure holes in trimmer beams and cross girders (filler beam floors) and shear studs (steel, filler beam and composite floors) are suitable to facilitate the accurate fixing of reinforcing bars and concreting.

7.2 Construction

When constructing the concreted areas of the standard E-type decks, the contractor must be careful to ensure suitable clearance between reinforcing bars is provided to allow concrete to surround all reinforcing bars. This is particularly relevant where the cross girders in the filler beam floors are fanned and the reinforcement will bunch in the narrow end. The designer should determine which bars can be curtailed in this situation.

The contractor should consider the use of vibrating shutters where the reinforcement is congested and limited access for pokers, such as casting the concrete behind the trimmer beam on steel floors.

8 SAFETY / CDM AND ENVIRONMENTAL

The general (non site specific) risks associated with the bridge design, construction and operation are listed on drawing NR/CIV/SD/1504. In addition there may be others arising from site-specific considerations, such as the presence of overhead line equipment (OHLE) or vulnerable services.

Environmental issues can only be determined on a site by site basis, bridge aesthetics including its colour, should be considered also.

The effect of renewing the protection scheme on the environment, particularly any watercourses, should be taken into consideration during the selection of the elements of the protection scheme.

Appendix A SCHEDULE OF STANDARD DRAWINGS

NR/CIV/SD/1500 Index of Drawings
NR/CIV/SD/1501 Key to Types - Filler Beam Floor
NR/CIV/SD/1502 Key to Types - Composite Floor
NR/CIV/SD/1503 Key to Types - Steel Floor
NR/CIV/SD/1504 General Notes and H&S Risk Register

NR/CIV/SD/1510 Steelwork General Assembly - Notes
NR/CIV/SD/1511 Steelwork General Assembly Details Double Track Square Filler Beam Floor
NR/CIV/SD/1512 Steelwork General Assembly Details Double Track 0° to 25° Filler Beam Floor
NR/CIV/SD/1513 Steelwork General Assembly Details Double Track 25° to 50° Filler Beam Floor
NR/CIV/SD/1514 Steelwork General Assembly Details Double Track Square Composite Floor
NR/CIV/SD/1515 Steelwork General Assembly Details Double Track 0° to 25° Composite Floor
NR/CIV/SD/1516 Steelwork General Assembly Details Double Track 25° to 50° Composite Floor
NR/CIV/SD/1517 Steelwork General Assembly Details Double Track Square Steel Floor
NR/CIV/SD/1518 Steelwork General Assembly Details Double Track 0° to 25° Steel Floor
NR/CIV/SD/1519 Steelwork General Assembly Details Double Track 25° to 50° Steel Floor

NR/CIV/SD/1525 Main Girder Details - Notes
NR/CIV/SD/1526 Main Girder Steelwork Details Double Track Filler Beam Floor
NR/CIV/SD/1527 Main Girder Steelwork Details Double Track Composite Floor
NR/CIV/SD/1528 Main Girder Steelwork Details Double Track Steel Floor Sheet 1 of 2
NR/CIV/SD/1529 Main Girder Steelwork Details Double Track Steel Floor Sheet 2 of 2

NR/CIV/SD/1530 Cross Girder and Trimmer Details - Notes
NR/CIV/SD/1531 Double Track Square Filler Beam Floor Cross Girder Details
NR/CIV/SD/1532 Double Track Square Filler Beam Floor Trimmer Details
NR/CIV/SD/1533 Double Track 0° to 25° Filler Beam Floor Cross Girder Details
NR/CIV/SD/1534 Double Track 0° to 25° Filler Beam Floor Trimmer Details
NR/CIV/SD/1535 Double Track 25° to 50° Filler Beam Floor Cross Girder Details
NR/CIV/SD/1536 Double Track 25° to 50° Filler Beam Floor Trimmer Details
NR/CIV/SD/1537 Double Track Square Composite Floor Cross Girder Details
NR/CIV/SD/1538 Double Track Square Composite Floor Trimmer Details
NR/CIV/SD/1539 Double Track 25° to 50° Composite Floor Cross Girder Details
NR/CIV/SD/1540 Double Track 25° to 50° Composite Floor Trimmer Details
NR/CIV/SD/1541 Double Track 50° Composite Floor Cross Girder Details
NR/CIV/SD/1542 Double Track 50° Composite Floor Trimmer Details
NR/CIV/SD/1543 Double Track Square Steel Floor Transverse Rib Details
NR/CIV/SD/1544 Double Track Square Steel Floor End Trimmer Details
NR/CIV/SD/1545 Double Track 0° to 25° Steel Floor Transverse Rib Details
NR/CIV/SD/1546 Double Track 0° to 25° Steel Floor Transverse Rib Details

NR/CIV/SD/1547 Double Track 25° to 50° Steel Floor Transverse Rib Details

NR/CIV/SD/1548 Double Track 25° to 50° Steel Floor End Trimmer Details

NR/CIV/SD/1550 Notes and Bearing Schedule for Standard Filler Beam Floor Bearings

NR/CIV/SD/1551 Notes and Bearing Schedule for Standard Composite Floor Bearings

NR/CIV/SD/1552 Notes and Bearing Schedule for Standard Steel Floor Bearings

NR/CIV/SD/1553 Steelwork Protective Treatment - Notes

NR/CIV/SD/1554 Filler Beam Floor Protective Treatment Details

NR/CIV/SD/1555 Composite Floor Protective Treatment Details

NR/CIV/SD/1556 Steel Floor Protective Treatment Details sheet 1 of 2

NR/CIV/SD/1557 Steel Floor Protective Treatment Details sheet 2 of 2

NR/CIV/SD/1560 Concrete and Reinforcement Details - Notes

NR/CIV/SD/1561 Concrete Details Double Track Square Filler Beam Bridge Floor

NR/CIV/SD/1562 Concrete Details Double Track 0° to 25° Filler Beam Bridge Floor

NR/CIV/SD/1563 Concrete Details Double Track 25° to 50° Filler Beam Bridge Floor

NR/CIV/SD/1564 Reinforcement Details Double Track Square Filler Beam Bridge Floor

NR/CIV/SD/1565 Reinforcement Details Double Track 0° to 25° Filler Beam Bridge Floor

NR/CIV/SD/1566 Reinforcement Details Double Track 25° to 50° Filler Beam Bridge Floor

NR/CIV/SD/1567 Concrete Details Double Track Square Composite Bridge Floor

NR/CIV/SD/1568 Concrete Details Double Track 0° to 25° Composite Bridge Floor

NR/CIV/SD/1569 Concrete Details Double Track 25° to 50° Composite Bridge Floor

NR/CIV/SD/1570 Reinforcement Details Double Track Square Composite Bridge Floor

NR/CIV/SD/1571 Reinforcement Details Double Track 0° to 25° Composite Bridge Floor

NR/CIV/SD/1572 Reinforcement Details Double Track 25° to 50° Composite Bridge Floor

NR/CIV/SD/1573 Concrete Details Double Track Steel Bridge Floor

NR/CIV/SD/1574 Reinforcement Details Double Track Steel Bridge Floor

NR/CIV/SD/1580 Waterproofing Details - Notes

NR/CIV/SD/1581 Waterproofing Details for Filler Beam Floor

NR/CIV/SD/1582 Waterproofing Details for Composite Floor

NR/CIV/SD/1583 Waterproofing Details for Steel Floor

NR/CIV/SD/1591 Ballast Plate and Filler Rail Details

Appendix B HISTORY

Although its history could not be fully documented, E-type decks were developed by British Rail for larger span bridges. Traditionally, a shallower depth floor was achieved using cross girders at 1.5m centres, with the top flange encased within a concrete slab and the slab haunched down to the bottom flange. The haunching was used to reduce the deck self weight, but had the disadvantage of positioning the concrete soffit and longitudinal reinforcement higher, thus limiting the effects of global bending on crack widths.

For the early developments of the E-type, the cross girders were connected to the main girder using a shear plate and 4 bolt endplate. This end connection minimised erection time during possessions, but was relatively inefficient in providing U frame stiffness. Therefore to provide a stiffer U frame connection, a deeper connection with a stiffened end plate was developed.

Over the years, there have been many developments of the E-type, particularly in the use of different floor types. The alternative floor types used include:

A steel floor, based upon the Tee rib floors adopted for the Western Region Boxes. The steel floor has been developed to reduce the weight of the bridge and allow easier installation. It is intended for use only where weight must be kept to a minimum.

A composite floor, applicable to bridges where the construction depth is not so critical. This alternative floor uses UC section cross girders (at up to 3m centres) with a slab on top acting compositely with the steel sections.

Traditionally, due to the size of the E-type elements, these bridges are usually constructed near to the existing structure and installed using transporters (SPLV) or sliding methods.

Appendix C DESIGN ASSUMPTIONS

Structural Models

The proposed new decks have been analysed using a linear elastic models of a complete deck. One corner of the deck was fixed in position. The bearings in the other corners allow rotation and movement longitudinally, laterally or in both directions. A quasi-static approach was used.

The trimmer beam is supported on the bottom flanges for all skews up to 25° and the end of the trimmer free to rotate. For 25° to 50° skews, the trimmer beam is independent of the main girders and supported on spherical bearings. The main girder bearings are line rockers and positioned to ensure restraint at the bearings is provided by the bearing stiffeners acting as cantilevers. At the obtuse corner of 25° to 50° skew decks, spherical bearings support the main girder.

The simple approach to fatigue assessment (without damage calculation) was used.

Loading

The following is a summary of the Eurocode design loads and draft Network Rail standard, NR/L2/CIV/020 (draft 12):

Permanent Actions

Item	Density / Load	Load Factor (γ_G)
Concrete	25 kN/m ³	1.35
Steel	77 kN/m ³	1.20
Ballast	21 kN/m ³ – depth 575mm over full floor area between webs of main girders (appropriate to 300mm depth under sleepers with additional average 100mm allowance for variations in ballast depth due to cant, track gradients, deflections etc). The weight of the top 300mm of ballast was factored by $\pm 30\%$ in accordance with NA BS EN 1991-1-1.	1.35
Track	6 kN/m (per track, includes sleeper and rail only, no allowance for ballast between sleepers)	1.35
Waterproofing	0.36 kN/m ² over floor area (equivalent to 15mm thickness at 24 kN/m ³)	1.35
Trackside Cables	1.0 kN/m (equivalent to 7 no. solid 40mm diameter lead cables)	1.35

Variable Actions

Load	Reference	Notes
LM71	BS EN 1991-2:2003 NR/L2/CIV/020	An additional a factor of 1.1 has been applied to provide adequacy in accordance with TSIs for high speed lines, or γ_{det} for standard lines. The total alpha factor used where applicable, $\alpha = 1.21$.
Dynamic Effects	BS EN 1991-2:2003	Factor taken as 2.0 for shorter span bridges, as detailed below.
Centrifugal Force*	BS EN 1991-2:2003	Value based upon $V = 120\text{kph}$, $r = 654\text{m}$ Maximum line speed 200kph.
Fatigue	BS EN 1993-2:2006	Damage equivalence method adopted Maximum traffic 42 MTPA
Walkways ⁺	NR/L2/CIV/020 – Draft 12	Uniformly Distributed load: 5.0 kN/m^2 Single Point Load: 2.0 kN Parapet Lateral Load on top rail: 0.74 kN/m
Longitudinal	BS EN 1991-2:2003	The track is assumed not continuous over the bridge for the purpose of distributing longitudinal live loads off the bridge, i.e. all longitudinal load resisted by the bridge.
Crane Loading (temporary case)	KIROW KRC1 200UK Rail Mounted Crane	Refer to NR/L2/CIV/020 for Axle Distribution, and reduced partial load factors apply.

Notes:

* - Maximum Centrifugal Force Factor (defined as the vertical effect of the centrifugal force on a girder expressed as a fraction of the static LM71 load): $0.2Q_{vk}$. Note that the designer must determine the minimum track radius a deck can accommodate, considering clearances, tolerances etc.

⁺ - These loads are used for the walkway, parapet, walkway bracket and main girder intermediate stiffener design.

Requirements for Main Girder Design

The design of the main girder, in particular the web thickness and web stiffener details that form the effective L or U-Frames, have been assumed in developing the E-type SDD floors. Details of the main girder were assumed and details are given on the relevant SDD drawings, e.g. geometric properties assumed are given on drawing NR/CIV/SD/1504 and typical web stiffener details given on drawings NR/CIV/SD/1525 to 1529. However, the designer must ensure that the main girder details are developed taking into account and checking the following issues, specific to the standard floors only:

- Main girder geometry ensuring; robust kerb provision, direct access to position of safety, capacity, clearances are suitable.
- Main girder maintenance provision, including provision of jacking points and ensuring a suitable load path of the jacking loads into the main girder.
- Web thickness and web stiffener details ensuring adequate lateral restraint (U or L frame) is provided to the compression flange is provided while checking that the cross girder / transverse rib to web connection is not over stressed.
- Web stiffener locations for walkway brackets and / or lifting lugs.
- Connection between the main girder and the floor for longitudinal load effects. Longitudinal shear connection may be required towards the deck ends where the standard connection between the main girder and the cross girder / transverse rib cannot take the U or L frame forces in addition to the longitudinal shear forces. Depending on the main girder detail and floor type, the longitudinal shear detail will be either shear studs for concrete floor or shear plates for steel floors. Where required, typical details and arrangements are shown on drawings NR/CIV/SD/1530 to 1548.
- The main girders must be designed and the main girder to cross girder / transverse rib connections checked for the relevant fatigue load.
- Longitudinally, due to global tensile effects, only the steel reinforcement, enhanced by the tension stiffening effect of the surrounding concrete should be considered in calculating section properties, strains and crack widths for filler beam and composite floors.
- Check that the main girder floor overhangs do not cause unacceptable vertical deflection.
- Check that the trimmer and its connection (e.g. keep plates or bearing fixings) can sustain the applied torsional effects resulting from wheel loads above the overhang.
- Check that the main girder and bearings can sustain the collision load requirements of BD60/04. Following discussion between Network Rail and the standard designs designer, the minimum flange thickness for SDD shall be 30mm, to provide suitable robustness against light impact. The weld between the main girder bottom flange shall be designed to distribute the codified collision load, considered as a point load applied to the outer edge of the bottom flange, without overstress of the weld. The designer must also consider using a suitable uplift restraint (upper section shown indicatively on the main girder drawings but lower section site specific as dependent on bearing details) noting that for longer span decks and high ballast depths, the designer may justify not providing the uplift bracket. Any uplift bracket has to be detailed ensure a suitable load path to the main girder is provided and the detail does not cause damaging prying effects in doubled bottom flange main girders. Detailing of the uplift bracket must consider main girder bearing replacement.

Requirements for Bearings and the Design of Bearing Stiffeners

Section 6.6 provides background to the bearing schedule values given on drawings 1550 to 1552. In addition to the bearing reactions, when specifying the bearings the designer must ensure:

- The deck articulation is as shown on drawings 1502 to 1504.
- The bearing make up complies with the arrangement shown on drawings 1502 to 1504.
- Access for main girder and trimmer girder bearing replacement.
- Load paths from the bearing to the main girder or trimmer girder.

The designer must design the bearing stiffeners to ensure the required deck articulation is achieved:

- For skews up to 25° , the main girder bearing shall be a rocker and the bearing stiffener designed as a cantilever. The designer may offset the bearing to take advantage of an eccentricity between the bearing and application of load, i.e. the main girder web.
- For skews above 25° , the main girder bearings in the acute corners shall be a rocker and the bearing stiffener shall be designed as a cantilever. The designer may offset the bearing to take advantage of an eccentricity between the bearing and application of load, i.e. the main girder web.
- For skews above 25° , the main girder bearings in the obtuse corners are required to be spherical (pot) bearings. The bearing restraint is provided by the bearing stiffener being part of an effective L frame or U frame.

Design of Floors

The 2009 E-type Standard Details provide three options for the deck type; filler beam floor, a composite floor and a steel floor. Details for the filler beam and composite floor were developed from other Standard Details and from examples of recently designed / constructed bridges. Steel floor details were based upon the previous Western Box Standard Types.

The choice of deck is based upon the required weight for lifting during construction, to minimise the load on abutments, or to achieve the required construction depths / clearances. The steel floor provides the shallowest and lightest option but the floor will be more expensive than either the filler beam or composite floor. The composite and steel floor details include a maintenance gap between the main girder bottom flange and the transverse rib soffit. This minimum gap must not be reduced to less than 50mm without the approval from Network Rail's professional head of civil engineering. The composite floor provides an efficient use of steel and concrete, but is often only applicable to schemes where the construction depth is not critical.

The standard E-type underbridge can be used up to a width between main girder centre lines of 9600mm, and down to a minimum 7005mm. The standard drawings show 9600mm wide decks.

Filler Beam Floor

The filler beam floor is assumed to act compositely in the transverse direction). The surface area acting to provide bond strength between the concrete and steel section is considered as only that acting in compression (locally, ignoring global tension effects). The effect of the composite concrete action at connections (notably U-Frame) has been ignored. Composite action has also been considered for the trimmer section.

Longitudinally, due to global tensile effects, only the steel reinforcement, enhanced by the tension stiffening effect of the surrounding concrete, is considered in calculating section properties, strains and crack widths.

For the filler beam floors, to provide additional capacity to resist longitudinal shear effects (see connections section below), the first cross girder connection should be a six bolt connection. Where additional longitudinal shear resistance is required, shear studs may be detailed to connect the concrete deck and the main girder web. Careful arrangement of deck reinforcement is required.

The filler beam floor (and concrete specification) has been designed to reduce early thermal cracking effects, to reduce the deck's susceptibility to chloride ingress, to limit the risk of spalling and to improve its durability generally. The concrete class at the soffit location has been taken as XD3 for chloride induced (corrosion, cyclic wet and dry) as the soffit is likely to be exposed to spray from potential highways below. The top surface is protected by waterproofing, and would be a lower classification. In determining nominal cover the value of Δc has been taken as $\pm 10\text{mm}$. The designer should consider applying a hydrophobic pore lining impregnant in accordance with Highways Agency document BD43/03 where the deck may be exposed to chlorides.

The distance between the filler beam soffit and the top of the main girder bottom flange is 50mm. However, where agreed with the professional head of civil engineering, this gap may be reduced to 25mm if the fabricator is able to weld the shear plates to the standard required and concrete with aggregate not exceeding 10mm is specified.

Composite Floor

Similarly the composite floor is assumed to act compositely in the transverse direction. Shear studs connect the concrete and steel cross girder. The whole depth of the concrete slab is in compression. The effect of the composite concrete action at connections (notably L and U-Frame) has been ignored. Composite action has also been considered for the trimmer section.

Longitudinally, due to global tensile effects, only the steel reinforcement, enhanced by the tension stiffening effect of the surrounding concrete, is considered in calculating section properties, strains and crack widths.

For the composite floors, to provide additional capacity to resist longitudinal shear effects (see connections section below), the first cross girder connection should be a six bolt connection. Where additional longitudinal shear resistance is required, shear studs may be detailed to connect the concrete deck and the main girder web. Careful arrangement of deck reinforcement is required.

The composite floor (and concrete specification) has been designed to reduce early thermal cracking effects, to reduce the deck's susceptibility to chloride ingress, to limit the risk of spalling and to improve its durability generally. The concrete class at the soffit location has been taken as XD3 for chloride induced (corrosion, cyclic wet and dry) as the soffit is likely to be exposed to spray from potential highways below. The top surface is protected by waterproofing, and would be a lower classification. In determining nominal cover the value of $\pm\Delta c$ has been taken as 10mm. The designer should consider applying a hydrophobic pore lining impregnant in accordance with Highways Agency document BD43/03 where the deck may be exposed to chlorides.

The maintenance gap (100mm) provided for the composite floor detail exceeds the minimum 50mm required. Should the designer wish, the detail shown for the cross girder end block may be modified ensuring:

- The maintenance gap is not less than 50mm.
- There is not less than 10mm clearance between the edge of any welds and the edge of the end block.
- There is sufficient space between the main girder bottom flange and the bottom of the end block for the main girder web to flange weld and the shear plate weld.

Note that the SDD allows 50mm (constant) between the shear plate and top of the main girder bottom flange.

Steel Floor

The concrete encasement of the steel floor trimmer has been ignored during the design stage. The concrete has been designed to resist early thermal cracking in accordance with Highways Agency Standards BD28/87 and BA24/92 and checks have been undertaken to ensure cracking is within the limits of BS EN 1992-2:2005. However the concrete has been included to reduce maintenance in and around the back of the trimmer section.

Longitudinal shear effects acting on steel floors, through the transverse rib connections and deck plate have been considered (see connections details below). As a result, shear plates bolted to the main girder webs may be required towards the ends of the main girder (with positive contact between shear plate and transverse rib shear plate). The size of the shear plate required, and the longitudinal extent along the main girder, is to be determined by the scheme designer.