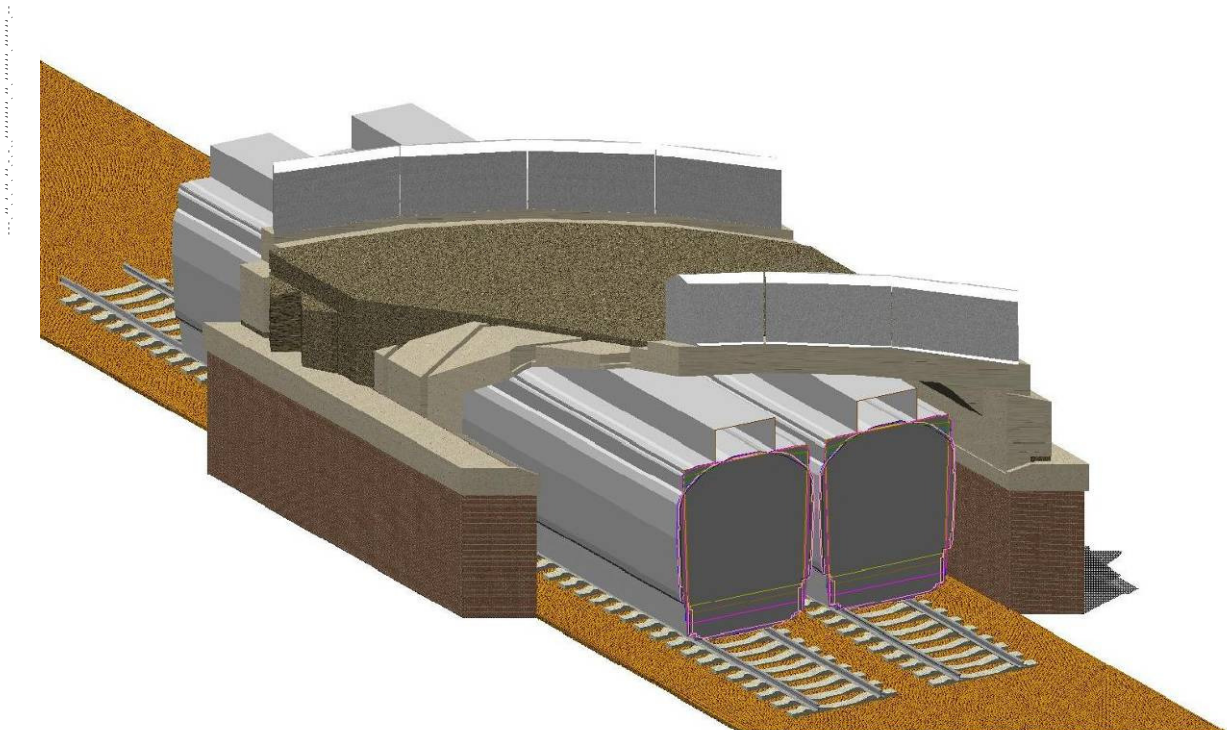


TECHNICAL USER MANUAL

for the use of

CONARCH OVERBRIDGE STANDARD DESIGN AND DETAILS



Summary

This technical user manual is applicable to the standard conarch overbridges. 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 superstructure replacement onto existing abutments but can also be applied to new structures.

Issue Record

This Technical User Manual will be updated when necessary by distribution of a complete replacement.

Revision	Date	Comments
A	October 2010	First Issue
B	October 2012	Second Issue

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EXECUTIVE SUMMARY

The Conarch Overbridge Standard Design and Details (SDD) have been developed to improve efficiency in terms of time scales and driving down the costs of reconstructing masonry arch overbridges. The SDD consists of a suite of standard drawings, a design spreadsheet (the Conarch Calculator) and this Technical User Manual (TUM). The intention is that the Scheme Designer uses these resources to produce a site specific design.

This TUM provides guidance to the Scheme Designer on how to use the SDD including how to use the Conarch Calculator and suite of drawings. The site specific design process is explained along with the background to the design and the parameters that have been used. The construction methodology is given and the safety, CDM and environmental issues associated with the SDD are discussed.

The suite of standard design and details drawings provide concrete general arrangement and reinforcement drawings for typical standard bridge configurations for spans of 7.4m, 8.4m and 9.4m with skews of 0°, 15°, 30° and 45°. These can then be adjusted to produce drawings for any bridge with a span between 7.4m and 9.4m in 5mm increments with 0° to 45° skew left or right with internal widths of 4.5m to 12.5m, allowing flexibility in the design.

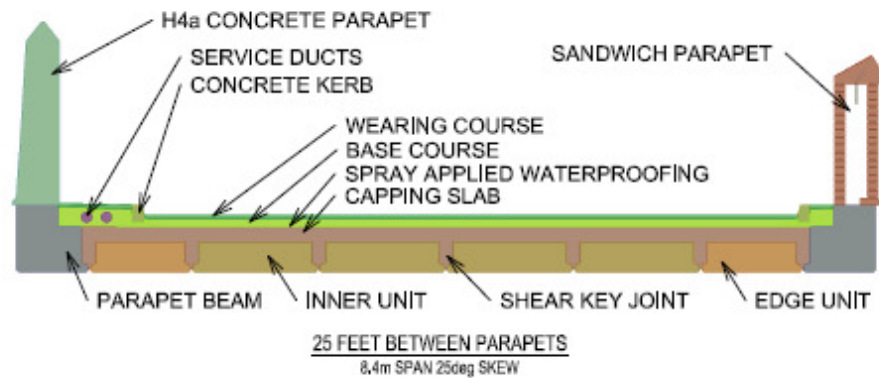
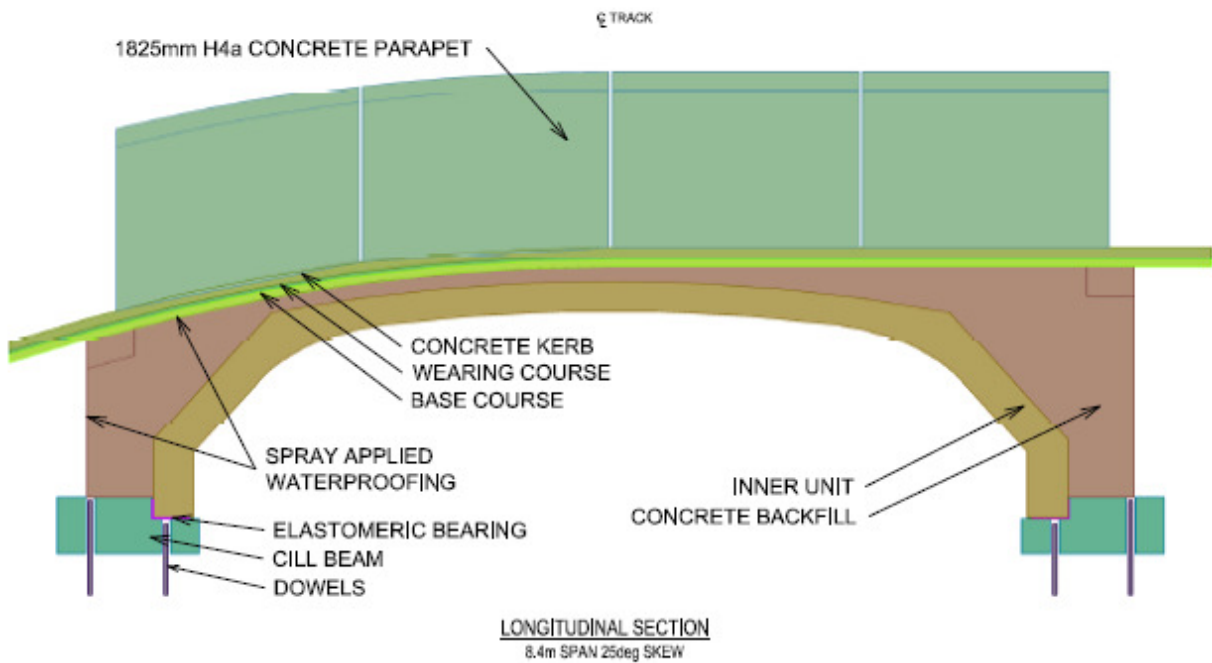
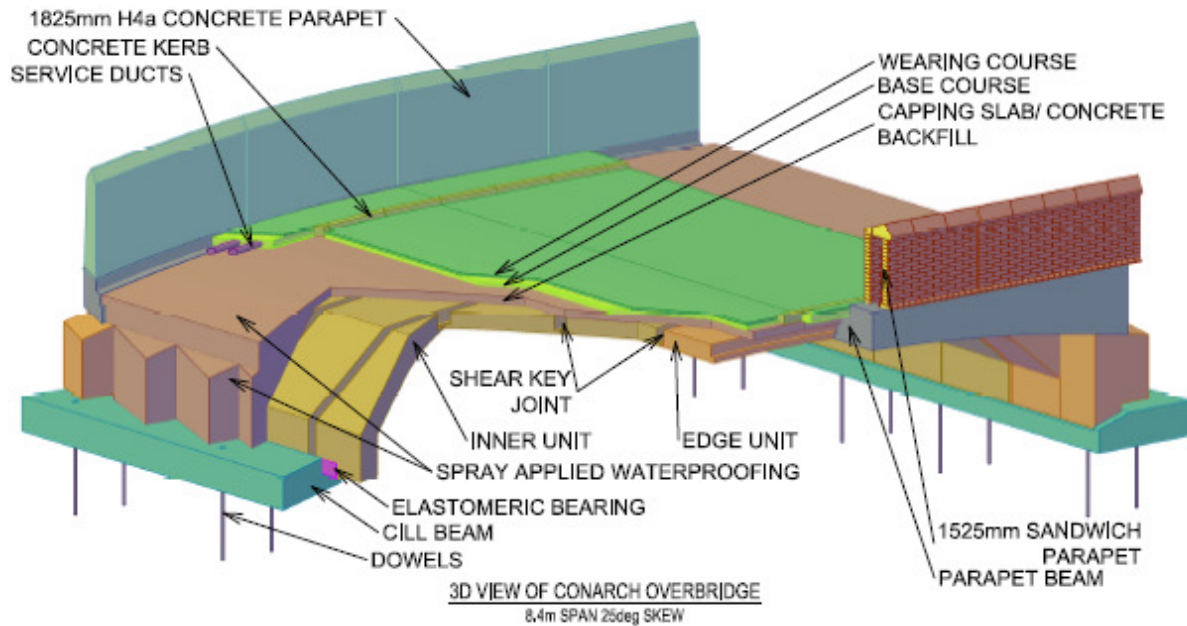
Using the SDD delivers benefits to everyone in the supply chain. These benefits are summarized in Table 1 and expanded upon in Section 1.2.

Table 1 - Table summarising benefits delivered by using SDD.

Benefit	Client	Contractor	Designer
Increased railway gauge clearance beneath the structure	✓		
Flexible geometry	✓	✓	✓
High containment parapets (H4a) provided over the structure	✓		
Reduced design time	✓	✓	✓
Initial feasibility can be undertaken in short timescale using Conarch Calculator			✓
Reinforcement schedules generated using Conarch Calculator			✓
High degree of standardisation throughout design		✓	✓

GLOSSARY OF TERMS

Reference diagrams:



Backfill/Backing	In-situ concrete fill behind the conarch units
Capping Slab	In-situ reinforced concrete slab on top of the conarch units
Cill Beam	Precast reinforced concrete member supporting conarch units, founded on the prepared existing abutment
Conarch Calculator:	Active design spreadsheet for use in site specific conarch design
Conarch Unit:	Precast reinforced concrete arch element
Elevation:	Elevation from the "train driver's" view
External Unit:	External precast arch unit
Internal Width:	Clear distance between inside face of the parapet panels perpendicular to the road centreline
Internal Unit:	Internal precast arch unit
Parapet Beam:	Precast reinforced concrete edge beam supporting parapet panels spanning between the cill beams
Parapet Panel:	Wall either side of the highway
Saw Tooth:	In-situ reinforced concrete saw tooth shaped fill behind the backfill
Shear Key:	Joint between adjacent precast units transferring vertical shear only
Span:	Clear distance between inside face of precast units, on elevation
Tie Bar:	Steel bar or cable between legs of arch unit tensioned to maintain the design span of the arch

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Transition Parapet:	Double rail open box beam safety fence extending from the structure through the transition zone on the approach to the structure
Transition Parapet Beams:	Reinforced precast concrete beams supporting transition parapets
Transition Slab:	In-situ reinforced concrete slab between transition parapet beams, a run-on runoff slab
True Section:	Section along the axis of a member or section perpendicular to the axis of the member
Tunnel Profile:	Soffit profile of precast units parallel to the tracks

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 objective, 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 one main areas that derive from these issues:

- Ensuring that the design meets Network Rail's requirements

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 (e.g. conarch overbridge design) 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 developed 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 driver 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 overbridges 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 vehicle strikes: The bridges have been designed to cater for codified vehicle strikes at road level.

These functional requirements are requirements of Network Rail standard NR/L3/CIV/020 Issue 1. This standard has been used and the requirements therein met in developing the standard designs and details.

A library of standard designs and details for conarch overbridges that meet these requirements has been produced. This document contains guidance on the selection and use of these standard designs and details.

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.

1.2 Benefits Delivered By the Conarch Standard Design And Details

The Conarch Overbridge Standard Design and Details have been developed to improve time and cost efficiencies of replacing masonry arch overbridges. This is required as part of Network Rail's gauge enhancement and overhead electrification schemes. This has been developed in addition to a Suite of Standard Drawings and Details a site specific design procedure that will suit a large range of bridge geometrical layouts. The site specific design procedure includes an active design spread sheet (Conarch Calculator) that the Scheme Designer uses to determine the basic structural layout parameters and the reinforcement schedules of the main precast units required for each structure.

1.2.1 Benefits at Each Bridge Location

The major benefits at each bridge location are as follows:

- Increased railway gauge clearance beneath the structure for both gauge enhancement and OHLE electrification schemes with minimum road profile changes across the structure.
- Flexible geometry:
 - Any span spans between 7.4m and 9.4m, increment of 5mm
 - Any skews between 0 to 45°, both left and right hand

- Any internal widths between 4.5m and 12.5m
- High containment parapets (H4a) are provided for each structure with standard details for the approach parapet transitions.
- Significant reduction in design time associated with the use of the Standard Designs for the precast units and associated standard details which can be generated utilising the Conarch Calculator.

1.2.2 Benefits to the Scheme Designer

The major benefits to the Scheme Designer are as follows:

- Initial feasibility of the overbridge reconstruction using the conarch units can be undertaken in a short timescale utilising the Conarch Calculator.
- All precast conarch units have been designed with available reinforcement schedules available for the internal units, external units, parapet beams, parapet panels and cill beams which can be generated utilising the Conarch Calculator.
- Significant reduction in design time associated with the use of the Standard Designs for the precast units and associated standard details.

1.2.3 Benefits to the Precast Concrete Fabricator

The major benefits to the precast concrete fabricator are as follows:

- For all spans the common central curved soffit tunnel profile is utilised for a length of 7.4m perpendicular to the track.
- For spans between 7.4m and 9.4m extension straight side soffit shutters formed of vertical and sloping sections are added to the main soffit 'Tunnel' unit to suit the specific site geometry.
- Units have a common central curved soffit tunnel profile perpendicular to the tracks with the two support legs formed with straight vertical and sloping sections. The span range is achieved by varying the height of the vertical and the length of the sloping components of the legs.
- High degree of standardisation on reinforcement layouts and details.

2 GUIDANCE FOR USE OF NETWORK RAIL STANDARD DESIGNS AND DETAILS (SDD)

This manual describes the standard for rail overbridges using a conarch construction. It is intended to be read in conjunction with the set of standard drawings listed in Annex 1 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 suite of standard design and details drawings represents typical standard bridge configurations for spans of 7.4m, 8.4m and 9.4m with skews of 0°, 15°, 30° and 45°. The numerous combinations of site constraints across the country means that the opportunities for directly applying the standard configurations, as presented in the drawings is potentially limited. Scheme Designers must therefore either demonstrate that a standard design can be applied directly or adapted accordingly to suit a specific site. This Technical User Manual in combination with the Conarch Calculator defines the process by which this is achieved.

The flowchart in Figure 1 demonstrates that use of the technical user manual, conarch calculator and standard drawings. Designers are required to analyse the constraints and requirements that exist for a specific project site. This Designer output, and the series of standard drawings can be combined to produce the final conarch overbridge solution.

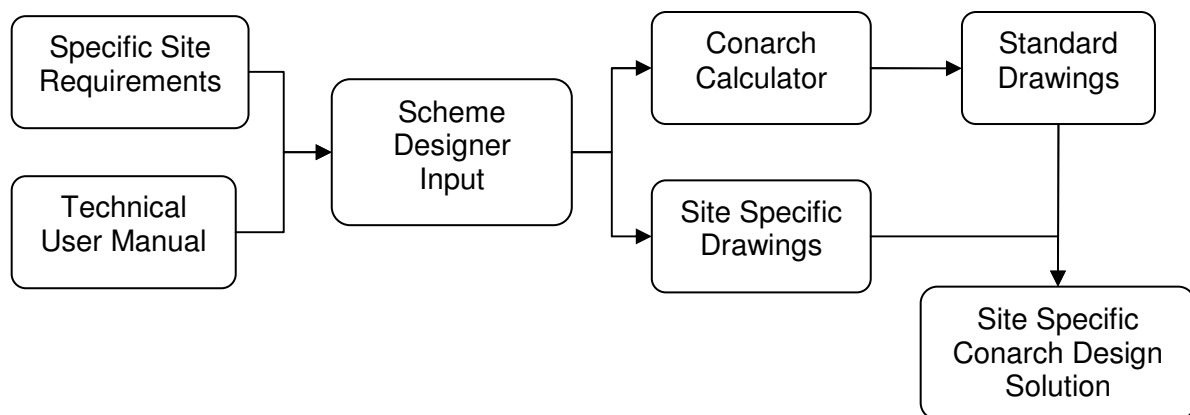


Figure 1 – Flowchart to show the use of Network Rail's Conarch Overbridge Standard Design and Details.

The designer is required to determine the bridge layout and produce scheme specific general arrangement drawings. The standard reinforced concrete drawings, accompanied by schedules produced from the Conarch Calculator, can be used for various skews. A list of the standard drawings used to define the required works shall be included on the site specific general arrangement drawing.

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

In catering for a range of spans and skews the standard conarch design necessarily incorporates conservatism on specific aspects of bridge arrangements. It may therefore be suitable for applications outside the specified skew/span parameters. **However it must not be assumed.** Proposals to the existing design in whole or part outside the given limits without modification, or to achieve a more efficient and less substantial design (e.g. lower weight) within those limits, but again in both cases they must be agreed with Network Rail's Project Sponsor and Network Rail's Professional Head of Civil Engineering.

2.1 Approval of Schemes Using Standard Designs and Details

The standard configuration design and details for conarch overbridges 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/SP/CIV /003 Issue 2.

. The following network Rail documents form part of the design approval process:

- Network Rail Form A document signed by DPE Bridges on 24th September 2008
- Tony Gee Addendum to Form A Document no. L109004/501/Addendum No.1 –Alternative Conarch Design dated 26th May 2009.
- Tony Gee Addendum to Form A Document no. L109004/501/Addendum No.2 – Eurocode Requirements dated 18th November 2009.
- Network Rail Form B document signed by SPEM on 18th November 2010.

The designer will need to produce a scheme specific F001, F002 and F003 in accordance with NR/L2/CIV/003 Issue 4 for the site under consideration. Annexe 4 provides a list of important information that should be included in these documents.

2.2 Standard Drawings

A Suite of Standard Drawings has been produced as part of the Conarch Overbridge SDD. A full list is included in Annex A of this document. The drawings can be split into categories as shown in Table 2.

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 the specific bridge scheme and concrete general arrangement drawings of the individual precast concrete units to be used in the bridge. The standard reinforcement drawings can be submitted along with a site specific bending schedule which is produced from the output of the conarch calculator, see Annexe 10.

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Table 2 - Standard drawing categories.

Drawing Series	Element	Drawing Type
NR/CIV/SD/2001	Notes & general layout	General
NR/CIV/SD/2010 - 2037	Internal precast concrete units	Concrete general arrangement
NR/CIV/SD/2040 - 2067	External precast concrete units	Concrete general arrangement
NR/CIV/SD/2071 - 2097	Precast concrete parapet beam units	Concrete general arrangement
NR/CIV/SD/2101 - 2107	Parapet units	General arrangement
NR/CIV/SD/2111 - 2138	Internal precast concrete units	Reinforcement details
NR/CIV/SD/2141 - 2168	External precast concrete units	Reinforcement details
NR/CIV/SD/2171 - 2175	Precast concrete parapet beam units	Reinforcement details
NR/CIV/SD/2201 - 2212	Cill beams	General arrangement and reinforcement details
NR/CIV/SD/2221 - 2229	Capping slab	General arrangement and reinforcement details
NR/CIV/SD/2231 - 2234	Transition parapet & beam	General arrangement and reinforcement details
NR/CIV/SD/2241 - 2242	Road surfacing & waterproofing	General arrangement
NR/CIV/SD/2251 - 2253	Lifting details	-
NR/CIV/SD/2261 - 2262	Finishing & cover	-

The standard drawings allow for skew spans between 7.4m and 9.4m and skews from 0° to 45°, both left and right handed skews. To enable the SDD to be applied to a wide range of situations, the Scheme Designer should produce site specific concrete general arrangement drawings by interpolating between the various spans and skews to produce a design for any site within the upper and lower span and skew limits i.e. if the design is for a 7.9m span with 18° skew then the designer should interpolate between standard drawings for 7.4m span with 0° skew, 7.4m span with 30° skew, 8.4m span with 0° skew and 8.4m span with 30°. Refer to Table 3 for which drawings have been produced at which spans and skews.

The standard drawings are not intended as fabrication drawings and fabricators should produce accurate site 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.

When using the Suite of Standard Drawings it is the Scheme Designer's responsibility to:

- Use the general arrangement and reinforcement drawings for the internal units, external units, parapet beams and parapet panels in conjunction with

the layout information from the Conarch Calculator to produce the layout drawings for the site specific conarch units.

- Determine the parapet profile and panel lengths using the proposed highway longitudinal profile.
- Determine the layout and geometry of the transition parapet beams to suit the vertical and horizontal highway alignments.
- Determine the width and length of the cill beams to suit the skew and width of the bridge.
- Determine the vertical and horizontal geometry of the reinforced concrete backfill from the proposed highway vertical profile and the skew of the bridge.
- Determine the vertical and horizontal geometry of the reinforced concrete capping slab from the proposed highway vertical profile and the skew of the bridge.
- Determine the vertical and horizontal geometry of the reinforced concrete transition slab from the proposed highway vertical profile and the skew of the bridge.
- Produce site specific drawings from the standard details for transition parapet layout, waterproofing, road surfacing, lifting details and the construction sequence.
- Develop the generic reinforcement schedules for the various elements to suit the site specific requirements.

Table 3 - Spans and skews for which standard drawings have been produced for various elements.

Element	Span and Skew											
	7.4m				8.4m				9.4m			
	0°	15°	30°	45°	0°	15°	30°	45°	0°	15°	30°	45°
Internal Precast Conarch Units	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Internal Precast Conarch Units Reinforcement Details	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
External Precast Conarch Units	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
External Precast Conarch Units Reinforcement Details	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Parapet Beam Units	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Parapet Beams Reinforcement Layout	✓											✓
Capping Slab General Arrangement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Capping Slab Reinforcement Details	✓			✓					✓			✓
Transition Parapet Precast Beam Reinforcement Details	Drawings produced for 0° and 45° skews for use at any span.											
Transition Slab Reinforcement Details	Drawings produced for 0° and 45° skews for use at any span.											

2.3 Modifications Outside of Scope of Standard Design and 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 and longevity with respect to fatigue:
 - F001, F002 and F003 documentation
- Cost justification
 - Estimate of the increased cost of maintaining non-standard assets
 - Estimate of the increased cost of additional Network Rail approval and review

3 CONARCH CALCULATOR

The Conarch Calculator is an active spreadsheet to assist a Scheme Designer with the detailing the conarch bridge design. The Scheme Designer should use the Conarch Calculator to:

- Generate the basic layout geometrical details of the proposed bridge reconstruction and use this information to produce the bridge layout drawings.
- Generate the reinforcement schedules for the precast conarch units and issue them to the Client for use by the unit manufacturer.
- Generate the reinforcement schedules for the in situ concrete.

3.1 Input Data

The required inputs to the Conarch Calculator are given in Table 4.

Table 4 - Conarch Calculator Inputs

Input	Limitations	Further Information/Guidance
<i>Bridge Location Details</i>		
ELR and mileage	No limitation	Site specific remit
Structure number	No limitation	Site specific remit
Location	No limitation	Site specific remit
<i>Railway Data</i>		
Proposed railway gauge	W6a, W8, W9, W9+, W10, W11, W12, WC1, WC1-A, Locomotive	Site specific remit
Overhead electrification	Yes, No	Site specific remit
Cant	0mm to 150mm	Site survey
Track Radius	>360mm	Site survey
6 Foot	1970mm to 2070mm	Site survey
Distance from top of highest rail to soffit of precast units at centre of span	Minimum value given by Conarch Calculator	Minimum value is a function of vehicle gauge and electrification requirements of the route generated by the Conarch Calculator.
<i>Structure Data</i>		
Clear distance between face of abutments	7400mm to 9400mm	The clear distance between the face of abutments measured perpendicular to the track. See Section 5.4.1.
Setback if required	Clear distance + setback must be less than 9400mm	See Section 5.4.1.
Skew	Between 0° and 45° "left skew",	See Section 5.4.2.

	"right skew" or "square".	
Clearance between parapets	Standard minimum clearance between parapets is 4500mm, maximum is 12500mm; absolute minimum 3570mm with stability check.	Standard minimum clearance between parapets is 4500mm, maximum is 12500mm; absolute minimum 3570mm with stability check. If clearance is between 3975mm-4484mm or 5270mm-5399mm bespoke internal unit is required. See Section 5.7.3.
Highway Data		
Carriageway	2750mm to 8950mm	Site specific remit
Cross-fall	1:27 to 1:40	See Section 5.7.5.
Road surfacing; Base course	Max 100mm	See Section 5.4.10 and 5.7.6.
Road surfacing; Wearing course	Max 60mm	See Section 5.4.10 and 5.7.6
Left verge width	125mm to 3500mm	See Section 5.7.5.6.
Left verge cross-fall	1:40 to 1:100	See Section 5.7.5.6.
Right verge width	125mm to 3500mm	See Section 5.7.5.6.
Right verge cross-fall	1:40 to 1:100	See Section 5.7.5.6.
Uplift to account for duct in verge	Max 95mm	See Section 5.7.5.6.
Vertical road alignment	"Horizontal" or "Circular vertical curve"	See Section 5.7.5.
Proposed road radius	No limitation	See Section 5.7.5.
Proposed road radius at top of capping slab	No limitation	See Section 5.7.5.
Parapet Data		
Gap between panels	20mm to 40mm	See Section 5.4.8.
Number of panels	3 or 4	See Section 5.4.8.
Height of parapet	1525mm to 1825mm	See Section 5.4.8.
Type of parapet	"H4a Concrete" or "Masonry Sandwich"	See Section 5.4.8.
Abutment Data		
Vertical load	No limitation	Determined by Designer
Horizontal load	No limitation	Determined by Designer