

**TECHNICAL USER MANUAL
for
UNDERBRIDGE ANCILLARY ITEMS**

Standard Detail and Design Drawings

Summary

This technical user manual is applicable to the standard ancillary item details for Network Rail's standard half through underbridges. The standard ancillary items designs and details will generally be used for new-build replacement structures, however may also be suitable onto existing structures and non standard underbridge types

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.

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GLOSSARY

Bearing	The elements between the cill/impost and the main girders on which the deck is supported.
Bridge	A deck and its supporting structure (e.g. cill/ impost, abutment or piers).
Cill	Alternative name for impost. The (usually) concrete beam on which the lower part of the bridge bearings are located.
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.
Dowel Restraint	A device to transmit load effects between deck, cill and abutment support.
Impost	Alternative name for cill. The (usually) concrete beam on which the lower part of the bridge bearings are located.
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.
TUM	Technical User Manual.
SDD	Standard Designs and Details.
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 taken 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 the on-going management and maintenance. 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.

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 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.

- Safe working environment: The bridges have been designed to minimise the risk to people on or about the bridge.

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 details for the underbridge ancillary items.

A library of standard designs and details for ancillary items to be used in conjunction with half through underbridges 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 design details are provided for the ancillary items (i.e. cill beams, ballast retention, protective treatment, waterproofing etc.), which are to be used in conjunction with other underbridge design details.

The flowchart in figure 2.1 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 underbridge ancillary items solution.

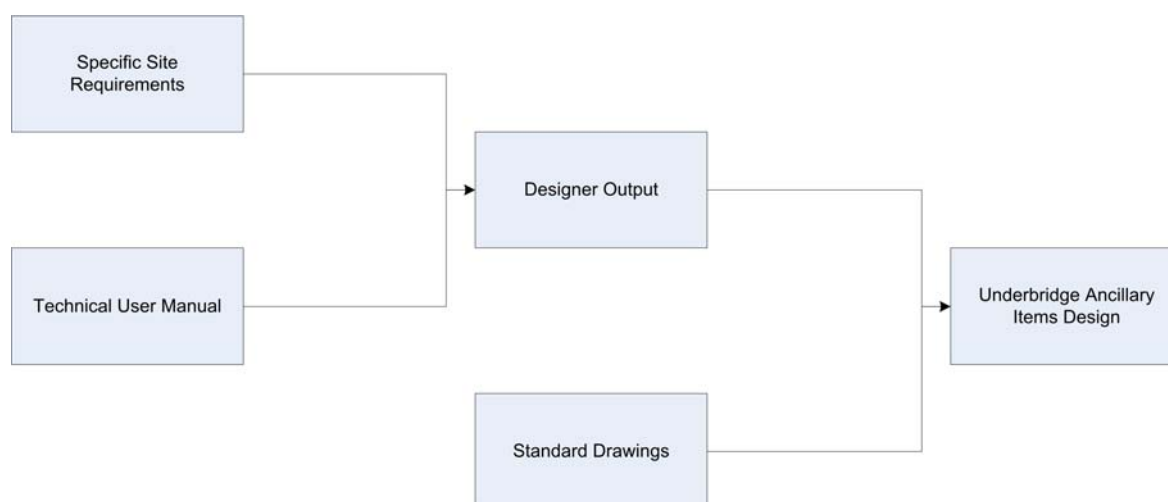


Figure 2.1: Flowchart to show the use of Network Rail's Standard Details and Designs

This manual describes the standard for rail underbridges ancillary items to be used in conjunction with half through deck type construction arrangements.

It is intended to be read in conjunction with the set of standard drawings listed in Appendix A.

General arrangements have been developed for reinforced concrete cill beam and deck end (four corners) ballast retention, waterproofing and drainage arrangements. The designer will still have to determine the most suitable arrangement and carry out scheme specific design of the cill beam, ballast wall / retention, substructure as necessary. In all cases, the scheme specific design will need approval, full design, and an appropriate check.

2.1 Approval of Schemes Using Standard Designs & Details

The SDDs for the underbridge ancillary items have been submitted and approved by Network Rail at both Form A and Form B (including a category II check) stages of the Network Rail approvals process.

The purpose of the underbridge ancillary items SDD was not to develop final / scheme designs but to provide best practice guidance and details that can be used in conjunction with the underbridge bridge forms.

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 and the SDDs that will be used. As discussed previously the SDD Form As have been approved and a site specific underbridge 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 need to produce a full suite of scheme specific drawings, including general arrangement drawings, detailed design drawings, reinforcement schedules and scheme specific details based around the SDD.

The level of checking required is:

- Category I Check of the application of the standard designs and details
- Category II Check of the site specific concrete cill beam and ballast retention design, general arrangement (including site survey information), detailed design drawings and bar bending schedules

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.

2.3 Drawing Selection Flowchart

The following flowchart assists the designer in deciding the options to select and which drawings to use in detailing the cill unit, ballast wall and deck end drainage and waterproofing:

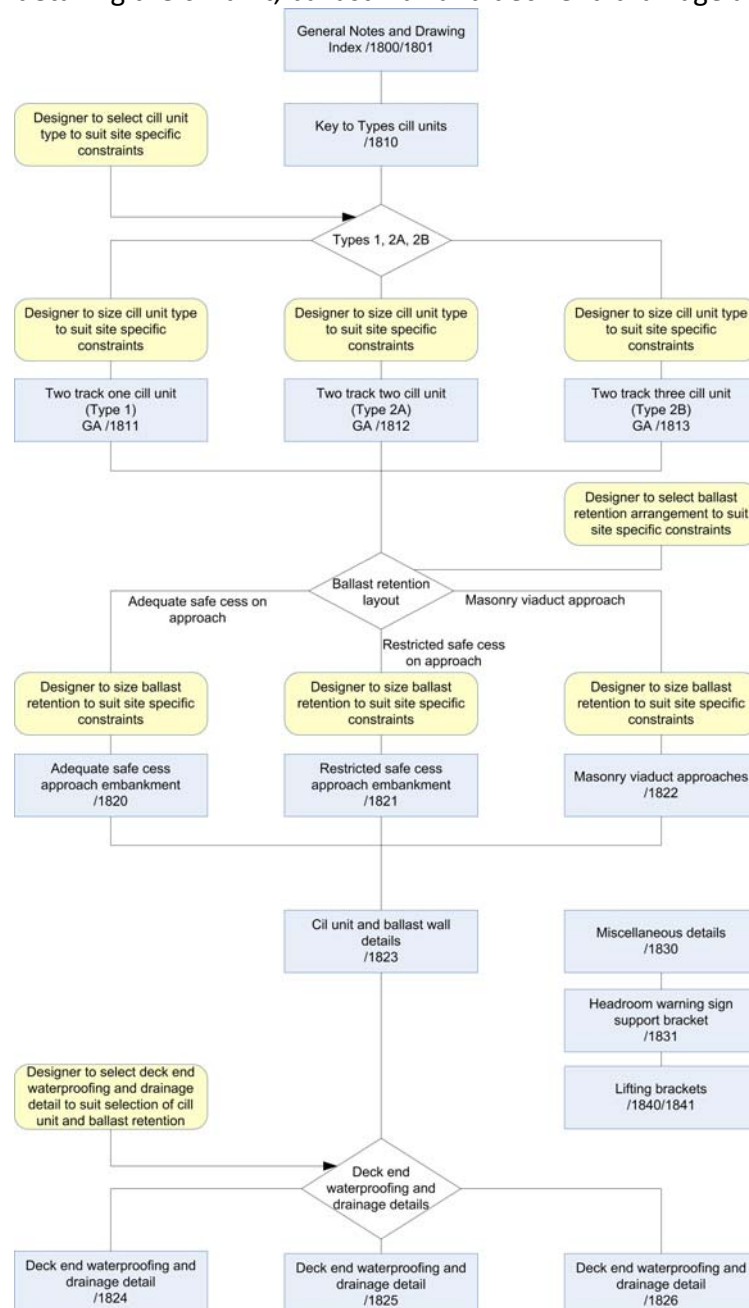


Figure 2.2: Process to determine the Standard Details and Designs to use in detailing a Standard Underbridge Ancillary Items

3 UNDERBRIDGE ANCILLARY ITEMS APPLICATION DETAILS

The standard drawings provide a complete set of preferred details for a range of ancillary items to be used in conjunction with underbridge replacement schemes. For a particular bridge, the designer needs to determine the specific layout, choose the appropriate arrangement and details to suit the site specific dimensions. This TUM gives guidance to help the designer determine the most suitable ancillary item arrangement.

It is intended that only those standard drawings relevant to the specific contract are to be modified to suit site specific dimensions and issued to the contractor as part of the contract drawings. The general arrangement drawings prepared by the designer will specify all principal dimensions and sizes, including material grades.

The designer should therefore choose the relevant drawings for his particular bridge from the full set of standard drawings and modify them as appropriate to suit the site specific contract. Refer to flowchart in Figure 2.2.

The drawings have been developed to be interchangeable between the various details shown and the designer is to select the preferred solution to suit the specific constraints of the site. The SDD has not attempted to reproduce every possible eventuality and are to provide guidance on potential combinations.

Cill beams can be either in one, two or three units depending upon the skew of the bridge and overall length of abutment. In some instances where the skew of the bridge is high or to suit specific lifting restrictions more than three cill units can be adopted.

The cill beam has three possible arrangements, Type 1 (block wall ballast wall), Type 2A (integral ballast wall), Type 2B (separate ballast wall).

There are typically three common situations on the approaches to the bridge (four corners) where the position of the cess walking route off the bridge is adequate, inadequate or has limited clearances (such as masonry viaduct).

The deck end waterproofing and drainage that has been shown takes account of the three typical scenarios but again can be interchangeable between details.

General arrangement drawings should be produced in line with Network Rail's requirements for the specific site. Scheme specific general assembly drawings should be provided.

The designer should provide detailed drawings of all components except the standard details provided for concrete profiles, interfaces between units, waterproofing and end of deck drainage.

All detailed concrete outline and reinforcement drawings and bar bending schedules are to be prepared by the scheme designer.

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

The check list (not exhaustive) in Figure 3.3, design responsibilities and notes.

UNDERBRIDGE ANCILLARY ITEMS STANDARD DETAILS – DESIGN RESPONSIBILITIES			
Element	Item	Standard Detail or Designer to Determine	Notes
General Arrangement	Cill unit Length / number of units	Designer	Site specific
	Cill Unit Skew	Designer	Site Specific
	Cill Unit Width	Designer	Site Specific
	Cill Unit Depth	Designer	Site Specific
Cill Units / Ballast Retention	Concrete	Designer	Designer to confirm concrete constituents in accordance with BS 8500 – 2: 2006.
	Reinforcement	Designer	Designer to confirm reinforcement arrangement and provide bar bending schedules
	Uplift Restraint	Designer	Designer to confirm requirement for uplift restraint interface between cill unit and substructure. Refer to Technical User Manual
	Lateral Restraint	Designer	Designer to confirm requirement for Lateral restraint interface between cill unit and substructure. Refer to Technical User Manual
	Joints	Standard	Designer to confirm requirement and select joint as appropriate.
Waterproofing and Deck End Drainage		Standard	Refer to Drawings NR/CIV/SD/1824, 1825 & 1826
Steelwork	Headroom Warning Sign support bracket	Standard	Refer to Drawings NR/CIV/SD/1831
	Vertical / Inclined Lifting brackets	Standard	Refer to Drawings NR/CIV/SD/1840, 1841

Figure 3.3: Check List for Standard and Non Standard Items

4 DETAILS OF STRUCTURAL FORM

The standard underbridge ancillary items comprise arrangements for two track cill units, ballast walls and associated ballast retention at deck ends. Standard details have been prepared for deck end waterproofing and drainage, lifting brackets and a headroom warning sign support bracket.

The designer will need to make a judgement as to the appropriate choice of cill unit, ballast wall and retention, including the deck end waterproofing and drainage arrangement as the existing bridge geometry and its approaches are bespoke to each underbridge reconstruction.

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 Rail Traffic Loading Requirements for the Design of Railway Structures.
- 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 Cill Units

Three types of cill unit have been detailed to cover a range of application to suit both the deck form and site constraints. The selection of the cill unit arrangement can vary to suit certain criteria as highlighted in 4 which is dependant upon the ballast wall arrangement as follows:

Cill beam Type 1 (low level integral concrete wall and blockwork ballast wall), 2A (integral ballast wall), 2B (separate ballast wall) all have discrete plinths in which the main deck units are supported from, which improves the access to the bearing shelf area. There is also the opportunity to post grout lateral / uplift restraints at the cill unit / substructure interface once the deck has been placed.

The integral ballast wall is recommended where one or more of the following would apply: time constraints do not permit the lifting of separate ballast walls and/or reinstatement of backfill

needs to be carried out immediately after placing the cill; construction tolerances are adequate to place a deck between two fixed walls; access to the rear of the bearings is not required when placing the deck. Where this is not the case, consideration can be given to having separate ballast walls at either one or both ends to suit site constraints.

The block wall ballast wall is recommended where either the spans are less than 10m (small movements) or where sheet membrane is used to waterproof the deck.

A typical gap between the end of the deck and cill unit / ballast wall should be 75mm (± 25 mm).

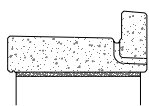
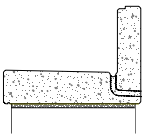
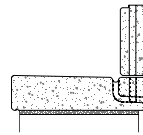
Cill Type	Type 1	Type 2A	Type 2B
			
Selection Criteria	<p>Suited for bridge spans of small movements (spans of 10m or less).</p> <p>Suited for use with sheeted membrane.</p>	<p>Suited for all bridge spans and deck forms.</p> <p>An integral ballast wall reduces the number of crane lifts and other site activities such as back fill material can be placed immediately after cill unit / back of wall drainage has been installed.</p> <p>Where cills are placed separately to the main deck sufficient construction tolerance is to be provided.</p>	<p>Generally as Type 2A but provides flexibility and more tolerance on placement of deck.</p> <p>Permits temporary access to rear of deck to assist in placement of bridge and any works that may be required to the bearings.</p> <p>Introduces an additional activity during the possession: ballast wall to cill dowelling.</p> <p>Level of ballast wall can be marginally adjusted to suit line and level that deck has been placed.</p>

Figure 4.4: Selection Criteria for Cill Units

The merits of locating the drainage channel in the cill unit towards the front of the cill unit was considered but not recommended on the basis that the water would have to run past the bearings in order to drain away and also the position of the bearings would be located further back on the cill unit making the cill units wider and spans longer leading to potential misalignment issues with the substructure.

Although access to maintain the drainage channel at the rear can be problematic, the designer is to consider potential locations where rodding / cleaning points can be made to suit site constraints.

4.2.1 Lateral Restraints

Lateral forces are to be resisted at all interfaces between the deck and supporting substructure. The deck is adequately restrained to the cill unit via the bearing assembly and likewise the cill unit must be adequately restrained against the existing substructure.

Lateral restraints between the cill units and the substructure are commonly provided by using stainless steel tie rods anchoring the cill unit to the masonry abutment / pier at suitable spacing and depth to generate sufficient lateral resistance.

Subject to design calculations single track underbridges of spans 12m or more do not generally require lateral restraints as they can rely on the inherent mass of the deck to provide the necessary frictional resistance between the substructure and cill unit interface. For the purposes of calculating the frictional resistance between the underside of the cill unit and mortar bed / masonry abutment a nominal coefficient of friction can typically range between 0.4 and 0.6, with the factor of safety against sliding generally assumed to be 1.5.

Where restraints are required between the cill unit and substructure, these are generally anchored to the masonry abutments by having pre-formed pockets in the cill unit and whereby an oversized hole can be cored through the pockets provided in the cills into the existing abutment to the required depth to achieve an effective embedment.

A threaded stainless steel tie rod is placed into the hole and a pourable cementitious grout is then pumped to fill the void between the bar and masonry core to the level of the top of the cill unit. A holding down plate and nut is hand tightened to provide the anchorage. The depth of embedment will vary depending upon the lateral load effect to be resisted but it is generally relied upon and subsequently sized by the vertical load effect from a vehicle collision (Refer to Section 4.2.2)

4.2.2 Uplift Restraints

Vertical forces are to be resisted at all interfaces between the deck and supporting substructure. The deck is to be adequately restrained against the cill unit and likewise the cill unit is to be adequately restrained against the existing substructure.

Uplift restraints between the cill unit and the substructure are generally the same restraint as the lateral restraint mechanism by introducing a grouted tie rod to the required embedment.

For short span single track bridges of around 6m span or less, special consideration should be given to uplift restraints as generally there is insufficient inherent mass to resist the applied load affects both in terms of the deck itself and the abutments.

The uplift restraint between the deck and cill unit shall be adequately restrained via the bearing assembly.

Dowelled restraints are normally positioned either side of the bearings so in the event of a collision from an oversized vehicle the potential movement of the cill unit is restrained at the bearing position. Furthermore, the designer is to size the cill unit and its reinforcement to accommodate these accidental load effects spanning between dowelled restraints.

The standard design and details show four restraints on the basis that at the ends of each cill unit the arrangement will be such to suit site specific constraints. It is often the case that there is sufficient substructure width to accommodate an additional holding down restraint at this location.

The designer is to calculate the embedment of the dowelled restraints noting that these typically penetrate the substructure between 2m (longer spans) and 5m (shorter spans) depending upon the mass of the deck and its ability to counteract the vertical load effect. The allowable bond between the grouted periphery of the dowel hole and masonry interface generally dictates the length of the dowel in most cases.

The designer is to give special consideration to multiple cill units where joints are provided near to bearing locations and ensure that sufficient restraint is provided.

4.3 Ballast Retention Units

There are typically three common situations on the approaches to the bridge (four corners) where there is a requirement to provide ballast retention to the ends of the deck to a point where the approach structure itself is able to retain the ballast. The first situation is where there is sufficient safe cess to land a standard walkway and does not require any special consideration to retain the ballast on the approach to the bridge, such as a wide embankment or embankment with high wingwalls. The second situation is where the approach embankment narrows at the point of the bridge and there is insufficient safe cess to land a walkway and therefore requiring the walkway to extend to a point where sufficient cess width exists. The final situation is a bridge that sited within a masonry viaduct and the cess walkways have limited clearance.

4.4 Protection on abutments or walls between adjacent decks

Personnel protection is required along the top of abutment walls or transverse infill walls located between adjacent separated bridge decks. Consideration shall be given to the risk arising from derailed trains striking or dislodging the protection, and the parts to which it is attached.

Generally, the protection should take the form of lightweight handrailing which complies with the additional requirements for lineside handrailing on underline bridge decks as defined within NR/L2/CIV/020 Draft 12.

Solid construction, e.g brickwork, blockwork or concrete walls, or upstanding extensions of abutments or transverse walls, should not be used.

4.4.1 Clearances

(i) Structure Gauge Clearances

The designer should:

- Ensure that adequate clearance is provided between existing and proposed vehicles and the structure.
- Ensure that the structure gauge considered for the standard designs 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 and cant (if any) will not result in encroachment on the structure gauge by any part of the deck or walkway.
- Prepare a gauging diagram(s) at Form A Stage.

(ii) Clearances Limits Affecting Design.

Generally, clearances will not affect the design of the ancillary items. An absolute minimum clearance of 25mm to the Lower Structure gauge is to be provided to the nearest edge of the reinforced concrete ballast retention units at each of the corners of the underbridge replacement.

Note that the designer should assess if this is acceptable for specific bridges, i.e. permanent way clearances and requirement to maintain gauge, track maintenance requirements or construction and installation tolerances, as a minimum clearance of 50mm is desired for possible future works.

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

4.5 Deck End Drainage and Waterproofing

4.5.1 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, should be incorporated in the overall bridge design to minimise maintenance requirements.
- Steel surfaces permanently exposed in the final structure are specified as receiving a protective treatment in accordance with NR/GN/CIV/002 and agreed with the scheme sponsor.

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

4.5.2 Waterproofing

The waterproofing system shown is based upon either an acrylic spray or sheet membrane system protected with a protective layer against local damage. The waterproofing details are shown on drawing NR/CIV/SD/1824, 1825 & 1826. Deck ends are waterproofed to ensure water drains from the deck to the back of deck drainage.

Where there are no limits on application, the use of a tightly bonded system (spray applied acrylic) is much preferred to a loose laid system (sheet membrane). This is because, with the former, leakages through defects are much likely to be small and, hence, affect only a small of a deck and so have little detrimental effect on the service life of the bridge.

4.5.3 Drainage

Positive drainage should be considered where possible. Details of drainage provision options are shown on drawing NR/CIV/SD/1824, 1825 & 1826. Generally, drainage locations and thus the profile of the back of the cill/impost 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 cill/impost to the rear of the abutment is often preferred even to the extent of terminating the waterproofing at the cill/impost drain.

4.5.4 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.

Where appropriate, concrete surfaces that may be exposed to chlorides (e.g. cill units & decks above highways) should receive a hydrophobic pore lining impregnant in accordance with Highways Agency Document BD43/03.

All buried concrete surfaces (such as cill units and ballast walls) should receive two coats of bituminous paint.

4.6 Lifting Brackets

Where the deck units are installed by lifting them into position by lifting eyes / brackets attached to the deck units, the designer should ensure that lifting points are located perpendicularly opposite to one another. Details are given on the standard drawings and assume that the standard 25t or 50t lifting brackets are used (refer to ancillary drawings NR/CIV/SD/1840 & 1841 for details of the brackets).

The designer is to ensure that the guidance provided in the individual underbridge TUM with respect to positioning of lifting brackets is to be followed.

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 (where appropriate), 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 top flange does not exceed the theoretical stresses at the end installation from permanent loads, unless lift specific stress checks are undertaken.

Specific calculations will be required of the designer if any other erection method is proposed.

4.6.1 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 deck unit. 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.
- 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 at SLS, 1 in 1000 along the abutment
- 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.

4.7 Headroom Warning Sign Support Bracket

Headroom warning signs are usually repositioned onto the replacement structure and standard details have been prepared to accommodate a range of bridge skews, sign sizes and geometry. The bracket for the sign is connected to two of the walkway cantilevered brackets and projects out in front of the walkway and can be orientated to the skew of the bridge to face on coming vehicles.

The Local Authority are responsible for specifying the requirements for the sign (Mandatory / Warning) and providing the necessary illumination.

4.8 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.

5 FABRICATION AND CONSTRUCTION

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.

5.1 Fabrication

The fabricator must pay due attention to the reinforcement location and orientation to ensure holes for the bearing assemblies in the cill units are free from reinforcement when casting to allow for the bearing studs to be located and provided sufficient tolerance in the holes.

5.2 Construction

When constructing the concreted areas, the contractor must be careful to ensure suitable clearance between reinforcing bars is provided to allow concrete to surround all reinforcing bars.

The contractor should consider the use of vibrating shutters where the reinforcement is congested and limited access for pokers.

5.3 Installation Guidance

The ancillary items (cill units / ballast walls) are usually designed to be lifted by cranes (mobile road cranes and rail cranes, size to be determined by the designer).

Specific calculations will be required of the scheme designer to check that the element under consideration can sustain the temporary load effects from the lift and specify the need for any additional reinforcement local to the lifting anchor, should this be required.

5.4 Trial Erection

As stated on drawing NR/CIV/SD/1801 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.

No trial lifts shall be undertaken until the bridge deck is structurally complete in accordance with standard and scheme drawings.

5.5 Installation Tolerances

The tolerances assumed in the standard design are for installation of the bridge decks by crane. The standard designs were developed assuming the decks could be positioned within 10mm 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. Similar tolerances would be assumed for the ancillary items, noting that installation by alternative methods will require these tolerances to be reviewed.

6 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/1702. 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

Description	Drawing
NR/CIV/SD/1800	Index of Drawings
NR/CIV/SD/1801	General Notes and H&S Risk Register
NR/CIV/SD/1810	Key to Types – Cill units
NR/CIV/SD/1811	Two Track Cill Unit (Type 1) General Arrangement
NR/CIV/SD/1812	Two Track Cill Unit (Type 2A) General Arrangement
NR/CIV/SD/1813	Two Track Cill Unit (Type 2B) General Arrangement
NR/CIV/SD/1820	Ballast Retention Layout For Bridge Reconstruction with Adequate Safe Cess Approach Embankments
NR/CIV/SD/1821	Ballast Retention Layout For Bridge Reconstruction with Restricted Safe Cess Approach Embankments
NR/CIV/SD/1822	Ballast Retention Layout For Bridge Reconstruction on Masonry Viaduct
NR/CIV/SD/1823	Cill Unit & Ballast Wall – General Details
NR/CIV/SD/1824	Deck End – Waterproofing & Drainage Details (Type 1A)
NR/CIV/SD/1825	Deck End – Waterproofing & Drainage Details (Type 2A)
NR/CIV/SD/1826	Deck End – Waterproofing & Drainage Details (Type 2B)
NR/CIV/SD/1830	Miscellaneous Bridge Details
NR/CIV/SD/1831	Headroom Warning Sign Support Bracket
NR/CIV/SD/1840	Lifting Bracket – Vertical Lift
NR/CIV/SD/1841	Lifting Bracket – Inclined Lift

Appendix B DESIGN ASSUMPTIONS

Loading

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

Collision Loads.

The cill units and associated restraints are to accommodate the load effects induced at the bearing positions in accordance with the load requirements of BS EN1991-1-7:2006.

Design of Concrete Components

The concrete class at the cill units has been taken as XD3 for chloride induced (corrosion, cyclic wet and dry) as the bearing shelf is likely to be exposed to spray from potential highways below. Areas protected (i.e top surface) by waterproofing could be a lower classification. In determining nominal cover the fixing tolerance, Dc 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.

Appendix C Hidden Parts

The standard designs and details have, where possible, practicable and in accordance with NR/L2/CIV/020 (draft 12), minimised the number of structural elements that are considered, i.e. that cannot be inspected from at least one side. The areas considered as hidden parts on the underbridge ancillary items are listed below with a description of how the details are protected and access is provided for inspection.

Item	Description of hidden part	Protection provided	Access provided
Dowelled restraint	Dowelled restraint connecting the cill unit to the substructure	Encased in grout that provides protection	None.

Appendix D Draft 12 of NR/L2/CIV/020 Design of Bridges & Culverts

Ref	NR/L2/CIV/020
Issue	1 (Draft 12)
Date	2008

Level 2

Design of Bridges & Culverts

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Issue Record

Issue	Date	Comments
1	 2008	New standard. Incorporates and supersedes RT/CE/S/007 : <i>Design loading for accommodation and occupation overbridges.</i>

Compliance

This Network Rail standard specifies mandatory requirements and must be complied with by Network Rail and its contractors **from.....**

It is permissible for projects that have formally completed GRIP Level 4 at the compliance date (i.e. acceptance of Form A in accordance with NR/L2/CIV/003: *Technical approval of design, construction and maintenance of civil engineering infrastructure*) to continue to comply with the Network Rail standards and other standards and requirements as identified in the Form A and not to comply with the requirements contained herein, unless otherwise stipulated in the accompanying Briefing Note or Network Rail's specific requirements for the project.

Reference documentation

Railway Group Standards

GC/RT5021	Track System Requirements
GC/RT5112	Loading Requirements for Design of Bridges
GC/RT5203	Infrastructure Requirements for Personal Safety in Respect of Clearances and Access
GC/RT5212	Requirements for Defining and Maintaining Clearances
GE/RT8073	Requirements for the application of standard vehicle gauges
GE/RT8025	Electrical Protective Provisions for Electrified Lines
GL/RT1253	Mitigation of DC Stray Current effects
GM/RT2149	Requirements for Defining and Maintaining the Size of Railway Vehicles

Railway Approved Code of Practice / Guidance

GC/RC5510	Recommendations for the Design of Bridges
GE/GN8573	Guidance on gauging.

Network Rail Standards

At the time of publication a new reference system for Network Rail standards was being introduced; the references given to the following standards are those anticipated to be adopted in their next issue.

NR/L1/CIV/044	Managing structures works
NR/L2/CIV/003	Technical approval of design, construction and maintenance of civil engineering infrastructure
NR/L2/CIV/017	Examination of Bridges and Culverts
NR/L2/CIV/035	Assessment of structures
NR/L2/CIV/037	Managing the risk arising from mineral extraction and landfill
NR/L2/CIV/039	Specification RT98 – protective treatments for Railtrack infrastructure
NR/L2/CIV/041	Waterproofing systems for underline bridges
NR/L2/CIV/067	Design of equipment support structures
NR/L2/CIV/071	Design of earthworks, earthwork remediations and geotechnical aspects of foundations for structures
NR/L2/CIV/076	Management of bridge strikes from road vehicles & waterborne vessels
NR/L2/CIV/140	Control and use of model clauses
NR/L3/CIV/001	Waterproofing for underline bridge decks
NR/L3/CIV/002	Application and reapplication of protective treatments to Railtrack infrastructure
NR/L3/CIV/008	Model clauses for specifying civil engineering works
NR/L3/CIV/025	The structural assessment of underbridges
NR/L3/CIV/202	Management of the risk of bridge strikes
NR/L3/TRK/030	Lineside security
NR/SP/ELP/21085	Design of earthing and bonding systems for 25 kV A.C. electrified lines
NR/SP/OHS/069	Lineside facilities for personal safety
NR/SP/TRK/038	Longitudinal timbers – design, installation and maintenance
NR/SP/TRK/102	Track construction standards
NR/SP/TRK/9006	Design, installation and maintenance of lineside drainage
RT/CE/S/007	Loads for occupation/accommodation bridges (<i>Superseded by this standard</i>)

Network Rail Structures Engineers Technical Advice Notes

SE/TAN/0038 Helical screwed pile foundations for equipment support structures

British Standards

BS 5268	Structural use of timber: Part 2: 2002: Code of practice for permissible stress design, materials and workmanship
BS 5395	Stairs, ladders and walkways: Part 3: 1985: Code of practice for the design of industrial type stairs, permanent ladders and walkways
BS 5400	Steel, concrete and composite bridges: Part 1: 1988: General statement Part 2: 2006: Specification for loads Part 3: 2000: Code of practice for design of steel bridges Part 4: 1990: Code of practice for design of concrete bridges Part 5: 2005: Code of practice for design of composite bridges Part 9: 1983: Bridge bearings Part 10: 1980: Code of practice for fatigue
BS 5628	Code of practice for use of masonry: Part 1: 2005: Structural use of unreinforced masonry Part 2: 2005: Structural use of reinforced and prestressed masonry Part 3: 2001: Materials, components, design and workmanship
BS 6799	Highway parapets for bridges and other structures Part 4: 1999: Specification for parapets of reinforced and unreinforced masonry construction
BS 7818: 1995	Specification for pedestrian restraint systems in metal
BS 8004: 1986	Code of practice for foundations
BS 8110 – 1	Structural use of concrete. Part 1: 1985 Code of practice for design and construction
BS 8300: 2001	Code of Practice - Design of buildings and their approaches to meet the needs of disabled people
BS EN 1317- 2	Road restraint systems Part 2: 1998: Performance classes, impact test acceptance criteria and test methods for safety barriers
BS EN 1990: 2002 Annex A2	Eurocode – Basis of structures design, Annex A2: Application for bridges

BS EN 1991-1-7	Eurocode 1: Actions on structures Part 1-7: 2006: General actions – Accidental actions
BS EN 1991-2	Eurocode 1: Actions on structures Part 2: 2003: Traffic loads on bridges
BS EN 50122	Railway Applications – Fixed Installations: Part 1: 1998: Protective provisions relating to electrical safety and earthing Part 2: 1999: Protective provisions against the effects of stray currents caused by d.c. traction systems
BS EN ISO 12944-3	Paints and varnishes Part 3: 1998: Design considerations.
N.A.D. for ENV 1991-3: 1995	UK National Application Document for ENV 1991-3: 1995 Eurocode 1 – Basis of design and actions on structures – Part 3: Traffic loads on bridges

Highways Agency standards

BA 9/81	The Use of BS 5400: Part 10: 1980 Code of practice for fatigue
BD 9/81	Implementation of BS 5400: Part 10: 1980 Code of practice for fatigue
BD 20/92	Bridge Bearings. Use of BS5400: Part 9: 1983
BD 21/01	The Assessment of Highway Bridges and Structures
BD 29/04	Design Criteria for Footbridges
BD 30/87	Backfilled Retaining Walls and Bridge Abutments
BD 42/00	Design of Embedded Retaining Walls and Bridge Abutments
BD 60/04	The Design of Highway Bridges for Vehicle Collision Loads
BD 65/97	Design Criteria for Collision Protection Beams
BD 74/00	Foundations
TD 19/06	Requirement for Road Restraint Systems

Her Majesty's Railway Inspectorate

Railway Safety Principles and Guidance: Part 2	Section A: Guidance on the Infrastructure Section B: Guidance on Stations Section C: Guidance on Electric Traction Systems
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Department for Transport

Managing the accidental obstruction of the railway by road vehicles

Strategic Rail Authority

Code of Practice: Train and Station Services for Disabled Passengers

International Union of Railways

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UIC Leaflet 719-R Earthworks and track bed construction for railways
 UIC Leaflet 774-3R Track-bridge interaction. Recommendations for calculations
 UIC Leaflet 776-3R (1st Edition 1989): Deformation of bridges

American Association of State Highway & Transportation Officials (AASHTO)
 Load and resistance factor design (LRFD) – Bridge Design Specifications

Institution of Civil Engineers

Burland and Kalra: Queen Elizabeth II Conference Centre: geotechnical aspects,
 Proc. Instn Civ. Engrs, Part 1, 1986, 80, Dec., 1479-1503.

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Supply

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Comments

The applicability and content of this standard will be reviewed on a regular basis. Written comments on the accuracy and utility of this standard will be taken into account when assessing the need for a new issue of the standard; such comments should be sent to the Standards and Assurance Engineer (Civil Engineering) at 40 Melton Street, London NW1 2EE.

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1 Purpose

This Network Rail standard defines the requirements for the Design of Bridges and Culverts, and other structures within the scope of this standard.

This standard contains requirements supplementary to Network Rail standard [NR/L1/CIV/044](#): *Managing Structures Works*. Compliance with this standard and with the standards referenced herein will, in respect of the Design of structures within the scope of this standard, ensure compliance with [NR/L1/CIV/044](#) and Railway Group Standard [GC/RT/5112](#) (Issue 1: *Loading requirements for the design of bridges*). At the time of drafting this standard, [GC/RT/5112](#) was being revised for Issue 2. This standard complies with Draft 3b dated May 2008 of Issue 2 of [GC/RT/5112](#).

2 Scope

This standard applies to the Design of the following types of structure, to those involved with the Design, and to those appointed by Network Rail to be responsible for the management of such structures:

- Bridges,
- Culverts,
- avalanche shelters (loads for Design shall be agreed with Network Rail),
- cut and cover structures,
- pipe bridges (except as identified below in this Clause),
- structures that support buildings over operational railway lines (but not the buildings),
- subways,
- elevated vehicle forecourts and ramps,
- any other structure required by Network Rail to be designed as a Bridge or a Culvert.

Examples of structures that are within the scope of this standard are included in Structure Category A as shown in **Appendix A**. The scope includes all Bridge substructures, and earth retaining or wing walls that are integral with the Bridge substructure, and other earth retaining walls adjacent to the Bridge.

Intersection Bridges, which carry a railway over a railway, shall be designed for the applicable requirements of both an Underline and Overline Bridge.

Bridges which neither carry the railway nor span over the railway, shall be designed for the most onerous applicable effects according to what the Bridge carries and what the Bridge spans over.

For the purposes of this standard, the use of the terms Bridge or structure shall be deemed to include Culverts and any other structure within the scope of this standard where applicable.

This standard applies to the Design of:

- all Bridges that are, or will be, owned or managed by Network Rail,
- all Bridges that are Shared with Outside Parties,
- so far as is reasonably practicable, all Bridges that are owned by Outside Parties, where failure of the structure has a potential to affect the safety of train operations.

This standard also applies to:

- all stages where permanent works are Taken Into Use in stages before final completion,
- all temporary works, as defined in [NR/L2/CIV/003](#): *Technical Approval of design, construction and maintenance of civil engineering infrastructure*, that are provided for the execution of such Bridges.

The scope of this document covers the Design of the following categories of work:

- repairs,
- strengthening,
- replacement of parts,
- renewal / replacement of superstructures or substructures;
- new Bridges,
- temporary Bridges.

Where existing Bridges are to have parts repaired, strengthened or replaced (including the renewal / replacement of superstructures or substructures), the requirements of this standard shall apply to the Design of such parts and the consequential effects on other retained existing parts.

Retained existing parts do not need to comply with the requirements of this standard providing (a) the loads and effects on such parts will not be made more onerous by the alterations or the addition of other parts, (b) the retained parts are not showing any signs of distress, and (c) the load-bearing capability of the retained parts meets Network Rail's requirements. However, consideration shall be given to bringing retained existing parts into compliance with this standard where it is reasonably practicable and economic to achieve compliance. Where structural works are to be carried out, **10.10** identifies requirements to strengthen or replace weak existing parts.

This standard is applicable to Designs for conventional railway traffic at associated conventional speeds including:

- passenger rail traffic with maximum permitted speed not exceeding 125 mph (200 km/h),
- freight traffic with maximum axle weight of 25 tonnes and maximum permitted speed not exceeding 60 mph (100 km/h),
- freight traffic with maximum axle weight of 22.5 tonnes and maximum permitted speed not exceeding 75 mph (120 km/h).

For rail vehicles travelling in excess of the above speeds, guidance shall be obtained from Network Rail's Professional Head of Structures.

This standard does not apply to the Design of the following:

- longitudinal timbers, which shall be designed in accordance with [NR/SP/TRK/038](#): *Longitudinal Timbers – Design, Installation and Maintenance*,
- gantries for signals or overhead line electrification (OLE),
- cable bridges,
- pipe bridges for which the Design basis stated in the AIP Submission is [NR/L2/CIV/067](#): *Design of Equipment Support Structures*,
- Outside Party pipelines and other undertrack crossings,
- buildings or other structures that are supported by a Bridge.

Earthworks associated with a Bridge shall be designed in accordance with [NR/L2/CIV/071](#): *Design of earthworks, earthwork remediations and geotechnical aspects of foundations for structures*.

Equipment support structures that are attached to a Bridge shall be designed in accordance with the requirements of [NR/L2/CIV/067](#): *Design of Equipment Support Structures* as applicable.

This standard covers structural aspects of Design and those aspects of Design relating to the safe movement of users (including clearances) and the provision of adequate protection to users. However, it does not cover other health and safety aspects of Design, such as choice of materials (e.g. exclusion of lead based paints), ventilation, means of escape, access platforms and ladders.

This standard incorporates those parts of Railway Approved Code of Practice [GC/RC5510](#): *Recommendations for the Design of Bridges* which Network Rail requires to be mandatory. The requirements of this standard shall take priority over [GC/RC5510](#), which at the time of drafting this standard was due to be withdrawn. However, the additional information and guidance for the Design of Bridges available in [GC/RC5510](#) should be used where not in conflict with this standard.

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In order to address potential effects of climate change regarding temperatures, an additional 10°C has been added to effective Bridge temperatures – see **Appendix B**.

The principal standards for managing structures works are shown in [NR/L1/CIV/044](#): *Managing structures works*.

3 Roles, responsibilities and competencies

Those appointing persons to positions with responsibilities to deliver the requirements of this standard shall ensure that appointees are competent and that they understand their responsibilities. Appointments, responsibilities and duties shall be documented.

The skill, expertise, training and experience of those employed on a Design shall be appropriate to the nature and complexity of the structure being designed. This competency shall be assessed by the person making the appointment.

The Construction (Design and Management) Regulations 2007 set out requirements for those managing construction / Design work with respect to competency.

Roles, responsibilities and competencies of those involved in the production and checking of a Design, and its construction, shall be in accordance with [NR/L2/CIV/003](#): *Technical Approval of design, construction and maintenance of civil engineering infrastructure*.

The responsibilities of Network Rail's Infrastructure Liability Manager as regards this standard are identified in **6.7** and **9.4.1**.

4 Definitions

Accommodation Bridge

A Bridge provided to maintain access to lands that were severed by the construction of the railway and which can only legally be used by the successor to the original landowner whose land was severed; however, subsequent public footpath and bridle rights may have been acquired by other users.

AIP Submission

The submission for approval in principle as required by [NR/L2/CIV/003](#): *Technical Approval of design, construction and maintenance of civil engineering infrastructure*.

Authorised Walking Route

A designated route providing pedestrian access to and egress from places of work (including booking-on points and stabling points) and which is suitable for use by persons not certificated in Personal Track Safety.