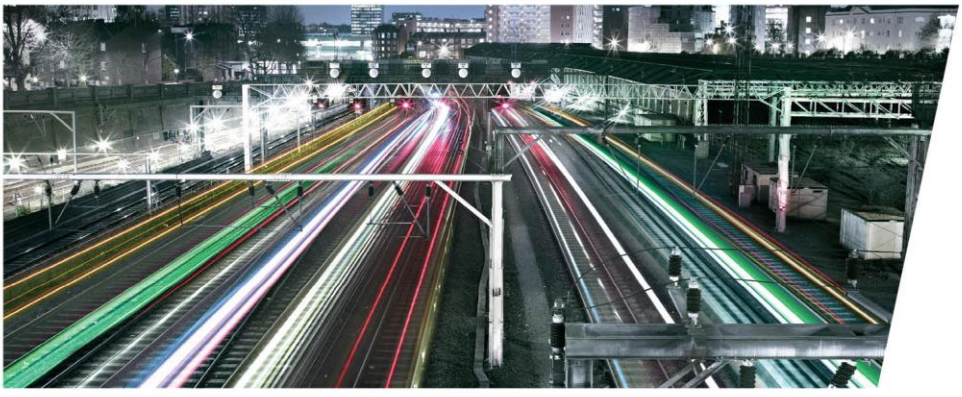
Health and Safety by Design, Buildings & Civils Working Group.

Guidance Note: Early Focus on Constructability and Temporary Works.

Issue 4. 16.11.2023.



NR Health and Safety by Design B&C WG	**Date:**	**16.11.2023**
Guidance Note – Early Focus on Constructability and Temporary Works	**Issue:**	**4**

Approval

Prepared by	See acknowledgements on page 4.	
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Version record

Version	Date	Comments
1.0	Nov 2012	Initial issue; Early focus on Temporary Works and Buildability.
2.0	16/04/2016	Second issue; Significant updates to all sections.
3.0	15/05/2019	Renamed; Early focus on Constructability and Temporary Works. Significant rewrite to all sections in a new arrangement, updated and new lessons learnt & good practice with narratives, new sections, expanded guidance and updates to all references.
4.0	16/11/2023	Updated to new & updated standards, new lessons learnt and good practice added, new section added, further advice & guidance provided, and appendices updated.

Disclaimer

In issuing this document for its stated purpose, Network Rail makes no warranties, express or implied, that compliance with all or any documents it issues is sufficient on its own to ensure safe systems of work or operation. Users are reminded of their own duties under health and safety legislation.

The requirements of Network Rail Standards listed in NR/CAT/STP/001, Catalogue of Network Rail Standards, RSSB standards, and Legislation such as the CDM Regulations, shall take precedence over the guidance in this document.

This guidance is intended to promote effective discussion and agreement. Suitable professional judgement, by suitably qualified and experienced persons, shall be applied when reviewing this guidance.

Issue 4 of this guidance was published 16.11.2023. Users should note the references herein may be superseded due to the passage of time since publication and they should always seek out the latest versions of any references herein.

Supply

Copies of this guidance document are available electronically to all, within Network Rail's "Safety Central" website at this link: https://www.safety.networkrail.co.uk

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Acknowledgements.

This revised guidance has been prepared by participants of the Health & Safety by Design Buildings & Civils Working Group (H&SbD B&C WG), with assistance gratefully received in particular by the following: -

Industry Partners	Network Rail
• Andy Barnes; Arcadis, • Chris Milne; Murphy Group, • Jeremy Barnes; Whitfield Consulting Services, • Tony Mclean-Thorne; B&M McHugh Ltd, • Steve Whitmore; Engauged.	• Eddie Haddad, • Andy Lannigan, • Steve Williams.

Section 1 Purpose / Background

The purpose of this guidance document is to improve awareness of, and to promote early focus on Constructability and Temporary Works. It is one of the guidance documents produced by the Health & Safety by Design, Buildings and Civils, Working Group (H&SbD B&C WG) which can be found in the below link: -

Building and Civils Working Group - Safety Central (networkrail.co.uk)

Constructability can be defined as:

"the extent to which the design of a building, civils structure or construction project and its environment facilitates ease of construction, subject to the overall requirements of the building, civils structure or construction project and its environment."

Temporary works can be defined as:

"those parts of the works that allow or enable construction of, protect, support or provide access to, the permanent works and which might or might not remain in place at the completion of the works, including states of the permanent works which are temporary, loading conditions of the permanent works not envisaged by the permanent works design and structures in states of modification or demolition."

Network Rail experiences a disproportionately high number of incidents / problems relating to Constructability and Temporary Works, some of which have had serious consequences including injuries, operational disruption, cancellation of work and "last minute" re-working/re-design, which imports safety risk and contravenes the principles of CDM.

Proper understanding and planning for Constructability and Temporary Works are a pre-requisite for the safe and smooth running of our projects and failure to do these imports unnecessary risk.

The aspiration is a thorough understanding of the site, identification of the assets that are affected and the asset owners, production of design that can be constructed as easily as is practicable, a thorough understanding of the risks, and a robust and workable plan – all put together by competent people as part of a joined up and collaborative approach.

Designers should ensure a safe, buildable construction methodology, accounting for all constraints and identifying requirements for temporary works from the outset.

This document endeavours to offer the reader experience from lessons learnt, capture best practice, and extol the virtues of an early focus particularly with respect to constructible design & implementation of Temporary Works within a railway environment.

Key points for this guidance are listed in **Appendix D**.

The guidance helps to enable the integration of permanent works designs with temporary works designs, using H&SbD B&C WG Principles. **

** Refer to the ICE Proceedings paper on embedding the integration of temporary works with permanent works on railway projects using H&SbD B&C WG Principles; refer below link.

Embedding integration of temporary works with permanent works on railway projects | Proceedings of the Institution of Civil Engineers - Civil Engineering (icevirtuallibrary.com)

The aim of the guidance is ultimately to prevent incidents such as the below from reoccurring.

Plate 1: Collapsed Scaffold

Scaffold system stability was by means of ties to a bridge. The ties were removed too early during dismantling works which led to whole system collapse. The ties were designed to support the system rather than individual scaffold components.

No one was hurt but this could have been catastrophic had it been in an urban environment. The lessons learnt is that the sequence of construction and dismantling/deconstruction needs to be detailed to ensure stability at all times, and the sequencing communicated to the workforce.

Section 2 Scope

The scope of this document includes Constructability and Temporary Works associated with building, building services and civil engineering projects/works on Network Rail Managed Infrastructure (NRMI), and/or such projects/works having the potential to affect NRMI through their use or failure, where any of NR standards NR/L2/RSE/02009, NR/L2/CIV/003, NR/L2/CIV/094&095&096, and NR/L2/CIV/0063, apply. However, much of the guidance may be applied as good practice elsewhere.

Although written by the Health and Safety by Design, Buildings and Civils, Working Group, the scope of this document is not limited to Buildings and Civils operations, but applies to other engineering disciplines, such as Track, Signalling and E&P, where there also exists the need for consideration of Constructability and Temporary Works. Principles are therefore intended for application to all engineering disciplines using a systems-based approach.

This guidance applies throughout the Project Life Cycle – Feasibility to Commissioning - and focuses on ensuring Constructability and Temporary Works are considered at early Project Acceleration in a Controlled Environment (PACE) stages. Allowing Constructability and Temporary Works issues to inform the Option Selection (PACE phase 2) process will enable activities past Option Selection to be developed which are aligned to good practice from the start.

This Health & Safety by Design document is intended as guidance to assist competent personnel to undertake their professional duties for the design and construction of works in a railway environment. It is not a replacement for knowledge & competence. It is not a design standard. It does refer to other materials contained within a range of standards and guidance notes to articulate a wide appreciation of the subject.

Section 3. Maintaining Operations (Business as Usual)

One of the major challenges when working on railway projects is maintaining ‘business-as-usual’ operations. This can be on station projects, bridge work, earthworks, tunnels and the permanent way etc. Closing the railway for any scheduled work requires extensive planning and co-ordination between many interested parties.

The need to maintain operations combined with the typically limited access available to carry out work creates considerable challenge on railway projects.

Works may need to be carried out in stages and/or alternative facilities constructed to maintain operation of the railway, including continuation of services to the public, including persons of reduced mobility. Examples of alternative facilities include, but are not limited to, new access points and access roads, duplicate services such as power and lighting, alterations to Station Information Security Systems (SISS) equipment e.g., PA/PAVA/CCTV/CIS systems, fire detection and suppression systems, smoke extract systems, alternative means of pedestrian flow, alterations to other security systems, and temporary station facilities such as waiting rooms, footbridges, alternative provision of temporary lifts, toilets, left luggage, etc.

Shutting down of the railway for carrying out work is costly; unscheduled over running of work can be very costly. Work carried out in such circumstances normally has strict time constraints and detailed half hour increment planning is normally required to ensure that 'hand back' of the railway infrastructure can be safely achieved on time.

Under such conditions it is critical to consider 'Health & Safety by Design' Principles** when assessing optimised solutions for all aspects of the work to be undertaken. Safety systems for personnel and materials handling should be considered and incorporated into all permanent and temporary work designs. Works under construction need to be safe and stable at all stages of construction, particularly when built over several stages with handback to normal operations between stages.

*NOTE** See H&SbD Principles on the Safety Central H&SbD B&C WG site. Link below: -*

Building and Civils Working Group - Safety Central (networkrail.co.uk)

Those planning the works should consider whether a safe system of work can be established that allows the railway to continue running. If a safe and practicable system cannot be identified, then the works may need to be undertaken when the railway is shut.

Section 4. Engineering and Hazard Management

NR/L2/RSE/02009, Engineering Management for Projects, is a key Network Rail standard which describes the processes and roles and responsibilities of staff responsible for the management of the technical and engineering requirements of projects for and on behalf of Network Rail.

It applies to all organisations working on projects; including Network Rail Alliances, Joint Ventures and Capital Delivery and maintenance teams responsible for the design, delivery and assurance of the engineering requirements of Projects, Programmes and Portfolios impacting Network Rail infrastructure, that:

- change, renew, enhance or remove the operational railway;
- are defined in NR/L1/CIV/094 as Third Party works, unless an agreed and documented arrangement is in place with Network Rail;
- are defined in NR/L1/CIV/094 as Outside Party works that require incidental changes to the Network Rail Infrastructure, unless an agreed and documented arrangement is in place with Network Rail.

There are several exclusions, as listed in the standard.

This guidance is applicable at all stages/phases of a project, including initial scoping, feasibility studies, option selection, design & construction, testing & commissioning, handover & handback, repair & maintenance, and eventual decommissioning & deconstruction.

The requirements defined within NR/L2/RSE/02009 detail responsibilities aligned to elements of the CDM Regulations. Network Rail standard NR/L2/OHS/0047 (Application of the Construction

(Design and Management) Regulations to Network Rail Construction Projects) defines the full responsibilities to achieve compliance with the CDM Regulations.

All IDC and IDR should be conducted in accordance with guidance provided within standard NR/L2/RSE/02009. The processes used for this should reflect the complexity of the designs and interfaces involved and provide a robust auditable trail.

It is important to identify engineering resource needs early in a project. For instance, the early identification of civils project engineering resource at the early stages of a Signalling, E&P or Track led project will help to assure adequate Temporary Works considerations are given at the appropriate time.

Network Rail is a railway duty holder and is required to use the Common Safety Method (CSM) for risk assessment, as specified in the Railways and Other Guided Transport Systems (Safety) Regulations (ROGS 2006, as amended). As part of this process a Hazard Record should be produced. Network Rail has specified the process for application of CSM Risk Evaluation and Assessment (CSM-REA, sometimes known as CSM-RA) in standard NR/L2/RSE/100/02; Application of the Common Safety Method for Risk Evaluation and Assessment.

A project hazard record as required under CSM-REA could be used to identify hazards that need to be controlled by suitable and sufficient risk assessment

Many engineering failures are primarily a result of poor conceptual design and/or modelling rather than errors in analysis method or design calculations. With a good conceptual model, conventional analysis and design techniques can provide an effective design solution and avoid the need for complex modelling which may sometimes add little real design refinement and can provide the danger of a false sense of design rigour or accuracy. The most important phase of the design is therefore the early establishing and testing of the conceptual model, particularly where existing defects are to be addressed.

Also refer to NR/L2/CIV/003, NR/GN/CIV/003 and other NR standards, which are discussed further in sections which follow. This section should be read in conjunction with Section 10.

Section 5 Understanding the Site: Record Information, Surveys, Logistics, and Access

Designing a scheme without an appropriate understanding of the site will lead to serious design problems; this is particularly true for the unique challenges of construction in a railway environment.

Under CDM Reg 4 the Client has a duty to provide site information at an early stage to the other CDM duty holders to help assist them with the safe planning and development of construction works, including for example records of existing assets, available Health & Safety Files and previous survey data. The CDM Pre-Construction Information should be adequate and complete (see HSE L153 guidance on the CDM Regulations and NR/L2/OHS/0047). Asset Managers and

Maintainers, who often have detailed records and knowledge of the infrastructure, should be contacted at an early stage once this is received.

A review of the adequacy and completeness of pre-construction information is essential. It should never be assumed that this information is sufficient for design and construction, or necessarily provides an accurate assessment of the site conditions and constraints. As a minimum, this review should include a detailed site inspection and obtaining any other readily available information not included within the pack provided. For example, BGS geological mapping and boreholes may provide significant information on ground conditions; EA Lidar data can be used to assess ground profiles; and free-to-use historical photos and mapping can confirm previous site uses.

No design should take place without an appropriate ground investigation and site inspection since without this it cannot be assumed that the design problem and scheme constraints have been fully understood. The site inspection should be undertaken by suitably competent persons, experienced in the aspects of engineering being addressed by the project, and should consider wider issues such as the access and logistics needed for construction. For large or complex schemes, attendance of a range of engineering specialists plus representatives of the Client and construction team may be required. The site inspection should include temporary works designers where significant temporary works are known to be required.

The object of the site inspection and information review is to develop a conceptual model of the engineering problem to be addressed, around which data gaps can be identified for the specification of additional surveys. Without this initial conceptual model, developed and tested throughout the design, the solution may be fundamentally flawed, and unnecessary or unfocussed surveys and investigations may be undertaken.

Appropriate engineering specialists should be used in developing the conceptual model. This might include specialist geotechnical advice to understand ground conditions and ground movement mechanisms and to apply a Geotechnical Design Category under EC7 to permanent and temporary works designs to determine the level of geotechnical design input required.

In planning ground investigations reference should be made to the requirements of NR/GN/CIV/208 (Ground Investigation) and NR/L3/CIV/071 (Geotechnical Design). It should be remembered that design of ground investigation is covered by the full provisions of CDM and the need for suitable design risk assessment. Note that Intrusive Investigations are considered to comprise Construction Works in the CDM Regulations and so a Principal Contractor must be appointed, and a Health and Safety File must be produced.

Mining activities have been carried out on or near Network Rail Managed Infrastructure over the years. Temporary works which might affect such works need careful consideration. Refer to NR/L2/CIV/191/05 Managing the risk from mining in design and construction

All surveys and investigations should be targeted to address risks to be resolved or refined. Surveys, particularly when intrusive, can be disproportionately expensive and without proper gap analysis can add little value. Depending on the level of risk and complexity of the design issue, use of conservative assumptions may be more cost-effective in some circumstances, provided that these are based on an appropriately developed conceptual model. Conversely early and well-

designed investigation can refine and define significant risks allowing more cost-effective design development. It should always be remembered that mass properties of soil and rock (for example obtained from back analysis / relevant existing information, or load testing) are always more representative than a small number of often expensive laboratory tests on recovered samples.

Appropriate baseline surveys may also be necessary to facilitate temporary works, e.g. noise surveys, lighting levels and potential for glare, which may affect local internal and external environments and sensitive receptors.

As the controlling mind in the design development, the CEM should consider the needs of all phases of the project and ensure designers are addressing where possible both permanent and temporary works survey and investigation requirements. For example, an additional window sample for a crane pad represents a modest additional cost when carried out within a wider scope of ground investigation works and may enable temporary works design efficiency.

See **Appendix F** as a warning to clients, and other members of project teams, of the need to review the capacity of existing structures to accommodate Temporary Works at early stages.

Section 6 Focus and Planning

Many of the problems caused by a lack of Constructability and/or inadequate consideration of Temporary Works are due to lack of focus and planning at an early enough stage in the project.

Lack of focus and planning at an early enough stage leads to late procurement, late submissions, compressed review times, disruption to works, lack of appropriate risk assessment, lack of understanding, and mistakes. It also leads to late change and poorly managed change, all importing risk.

Constructability, based upon the site and its constraints, should be reviewed at several stages/phases of a project, particularly early stages/phases of feasibility, option selection, & approval in principle, as well as a detailed design. It should not be left until construction stage, the key point being that the later Temporary Works are considered, the more difficult and costlier it is to make any necessary adjustments to the design. On complex projects it may be necessary to hold Constructability Reviews (see section 18) as design develops and understanding of the design and construction issues increases. Site teams may then use the outputs from early constructability reviews as their points of reference, rather than starting again.

On occasions, project teams do not recognise a situation as being a temporary condition, or Temporary Works until it is too late to implement solutions, leading to imported risk. For instance, a permanent structure being put into a temporary condition because of working nearby, or applying sudden live loads, or even unexpected temperature changes, or wind shielding caused by removing shade. Early identification of situations where Temporary Works design is needed will allow adequate time for design.

An early understanding of Temporary Works requirements and staging is essential to robustly understand the true scope of works and the associated risks. To achieve this the early

involvement of Designers with confirmed Temporary Works and Constructability competencies, or the use of Early Contractor Involvement (ECI) to test Constructability, is of great benefit. Indeed, early consideration of Constructability might influence the design significantly, such as agreeing connection locations and lifting points to allow practicable component transport. It might also reduce or eliminate the need for Temporary Works in the first place.

This early understanding can also be achieved by ensuring the Contractor appointment has an appropriate design competency either in-house or outsourced. It might also be beneficial for Network Rail to input into this appointment based on direct experiences of the Designers proposed.

ECI can also reap benefits for Constructability, with the Designer and Contractor working together to seek the most efficient constructible solutions to promote maximum safety and efficiency. This requires a contracts and procurement strategy to enable ECI. (Refer also to Section 17)

In some cases, tender returns include Suitably Qualified and Experienced Persons (SQEP) to undertake these roles, but when the tenders are let less experienced persons are offered. Projects should insist on the retention of the SQEP where possible.

Designers should also provide a Pre-Construction Temporary Works Schedule at the earliest possible stage. All parties can then review and comment to gather the broadest possible views on Temporary Works and Constructability. Table 1 is a suggested Pre-Construction Temporary Works Schedule template.

Table 1 – Suggested Pre-Construction Temporary Works Schedule Template

Permanent Works Element	Anticipated Temporary Conditions	Identified Risks (also refer to Designer's Risk Register)	Can Temporary Condition be avoided by Design modifications?	Are Temporary Works anticipated? (Describe)

This should not be confused with the Temporary Works Register which is intended to feed from the Pre-Construction Temporary Works Schedule in readiness for the Construction Phase. Refer to Section 10 for commentary on the separate use of a Temporary Works Register.

Constructability Reviews (See also Section 18 and **Appendix A**) should encompass assessments of Temporary Works at an early stage.

It is considered good practice for the NR Project Manager/DPE to work with the PD, PC, TWC and Designers to enable the Temporary Works Register to be combined with the projects Permanent Works Register and Work Package Plan Register. This will help enable a consideration of integration between Permanent Works Designs, Temporary Works Designs and Works Package Plans as the designs are developed

It is also considered good practice to involve CREs responsible for construction (CREc) with CREs responsible for the design (CREd) to assist with constructability.

It is also considered good practice to involve NR Construction Managers in the development of temporary works designs, where experience of sites may prove invaluable in seeking out the most efficient solutions. Construction Management within NR is covered by NR/L2/CONM/01 Construction Management for Projects, and associated modules.

Great care and engineering attention to planning is needed during design, with close on-site supervision & planning in the execution of temporary works schemes, to ensure safety.

NR/L2/CIV/003 calls for a consideration of constructability (including requirements for temporary works and construction sequencing) at feasibility stage. It then calls for a constructability review at option selection stage. It also calls for consideration of constructability at Approval in Principle stage; refer clause 11.5 i) and note 7. There is also a requirement that the Principal Contractor should be consulted at the earliest opportunity to look at constructability, particularly where fulfilling the temporary works requirements might impinge on clearances, or lead to temporary hazardous conditions that can be designed out as part of the permanent works design (e.g. eliminate restricted clearances or reduced working at height).

For instance, temporary works are specifically included within section 1.4 of the FormA, which states: -

> *"...*The Permanent Works Designer is to identify construction methodology and sequencing for the chosen design and all significant items of temporary works, known be required to facilitate construction at Approval in Principle (AiP) stage, below. This is to include temporary facilities needed to facilitate compliance with the DIA, such as the provision of temporary footbridges, hoardings, alternative means of escape, phasing, and such like..." *and,*
>
> *"...*The Permanent Works Designer is to consider impact from other disciplines on the provision for temporary works, e.g. for services and other equipment supported on temporary works..."

With a constructability review in place the IDC & IDR will be able to consider both permanent works and temporary works interfaces with other disciplines. By way of example of (mandatory) IDC & IDR activity, take the provision of a complex scaffold structure to gain access to the roof above a concourse of a major station, for roof repair/refurbishment. Whilst the scaffolding system may be reasonably straight forward, the team will need to consider interdisciplinary matters such as, but not limited to the below: -

- Fire assessment to confirm station fire strategy will not be compromised – or what the temporary mitigations are
- Security team input to location of hoardings, doors, inspection windows, etc.
- Confirmation that hoarding lines so not significantly affect pedestrian flows and mitigation measures are in place
- Temporary lighting design (main and emergency) may be significantly affected by the scaffold and may require building services changes.
- Fire detection system impacts

- Smoke extract impacts
- Affects on Station Information Security Systems (SISS) equipment e.g., PA/PAVA/CCTV/CIS systems, any of which may be affected by the temporary works.
- Foundation design – a typical scaffold design may stop at support level, but foundations such as suspended platform floor structures will need assessment and design submissions.

Section 7 Capturing and Cascading Lessons Learnt and Good Practice.

For engineers, and others, it is important that they understand what they don't know and seek advice from colleagues/contacts as appropriate. Furthermore, CEMs and CREs should seek advice/opinion from Network Rail engineers and others.

Consideration should be given to holding a "lessons learnt" meeting at an early stage of all projects. This should include holding a workshop and inviting people who have previous knowledge of similar projects.

Lessons learnt information is available on Safety Central at link below.

https://www.safety.networkrail.co.uk

Network Rail also has a Learning from Lessons Library which is available to the supply chain. To view the library users must request access to register, at the below address.

Learning from Lessons Library - Home (sharepoint.com)

Section 8 Building Information Modelling (BIM)

More projects are designed using the many advantages of building information modelling and Network Rail has embarked on a programme of ensuring future programmes make best use of BIM. In the context of this guidance BIM enabled projects can be especially useful for the following:

a) Capture reality i.e. ensure that surveys reflect existing infrastructure hence new permanent and Temporary Works designs fit.

b) Cut down rework by detecting clashes so that IDC/IDR is efficient.

c) Intelligent planning (4D) to allow sequencing of activities, which might influence both permanent works and Temporary Works design.

d) Intelligent planning for unforeseen changes, such as the need to resequence work leading to alternative design solutions.

e) Promotes collaborative working using a common data environment.

f) Resolves conflicts between designs within the design process, at greatly reduced costs compared to redesign on site.

g) Reduces the potential for errors and omissions, leading to better project efficiency

h) Improves safety.

i) Leads to better records of the as built design to be used in future maintenance and refurbishment.

Projects should consider the advantages of BIM at early PACE stage and to maximise the benefits throughout the project lifecycle projects should consider the creation and use of a Digital Twin as early as possible in the lifecycle. Projects should also consider the adoption and use of a common design file format such as a IFC (International Foundation Class) which would aid the integration of specialist TW designers design into the projects federated model.

Furthermore, projects should consider the inclusion of specific requirements within their Lead Design Organisation / Design Organisation remit (NR/L2/RSE/02009 Appendix A) to promote the early identification of temporary conditions and temporary works during the technical integration phase of the project lifecycle.

There are many emerging requirements for projects to follow a common data environment and ensure that deliverables are BIM compatible to PAS 1192, and latterly to IS0 19650 and all NR BIM requirements.

The Manchester Victoria Station Redevelopment project was an early example of the development of a complex multi discipline railway project in a BIM environment.

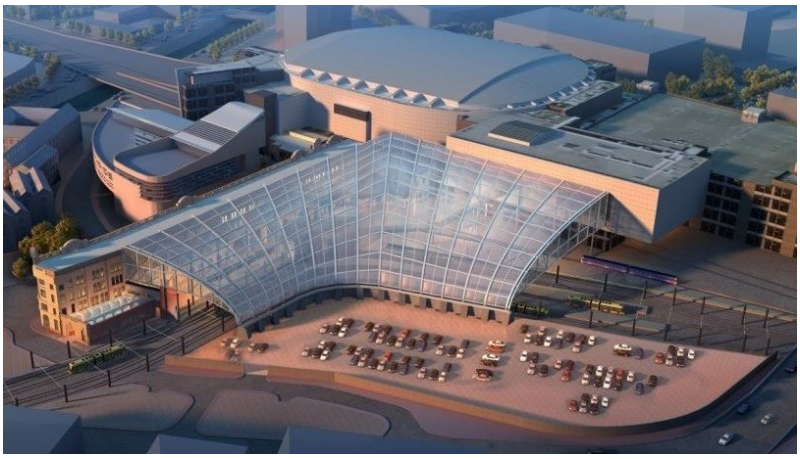


Plate 2: Manchester Victoria Station Visualisation from complete BIM model

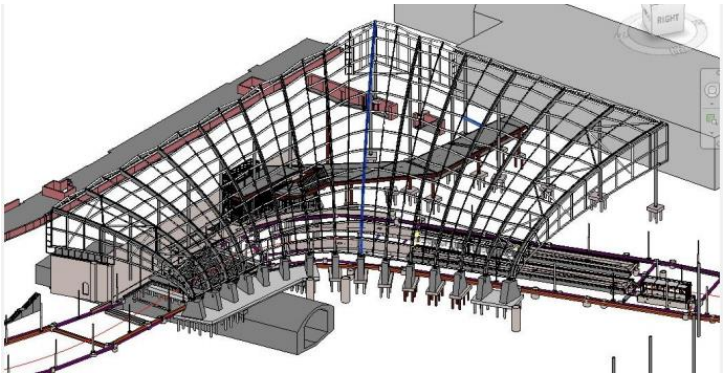


Plate 3: Manchester Victoria Station Developing BIM model with key interfaces.

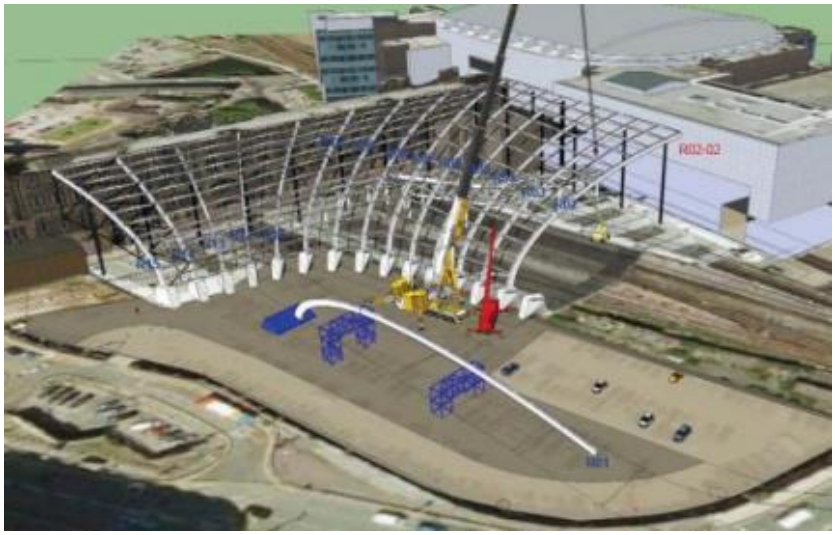


Plate 4: Manchester Victoria Station Erection Sequence, Temporary Works and Lift Planning within the BIM model.

A major benefit of all disciplines working within the BIM environment from conception to fabrication enabled clarity and consistency of thought around Constructability and Temporary Works in a congested city centre site.

Plate 5: Birmingham New Street Atrium temporary decking.

A good example of the use of BIM was with the innovative Temporary works used to provide access to clad the Atrium structure at Birmingham New Street. Delays to steel erection due to adverse weather meant that the deconstruction sequencing of the structure below needed to continue to maintain overall programme, resulting in the need for new Temporary Works. The BIM model allowed the swift identification of the issues and the timely design of the innovative Temporary Works shown above, making use of BIM to coordinate temporary and permanent works designs, identify suitable fixing points and confirm overall sequencing.

Section 9 Listed Buildings and Structures

Network Rail owns a significant number of listed buildings and structures. These attract legal requirements and necessitate stakeholder consultation.

When working on listed buildings and structures early consultation with Historic England / English Heritage / Cadw (for relevant projects in Wales) / Historic Scotland is advised to understand the constraints and consultation requirements.

Temporary works in this environment may require the same level of attention as the permanent works in terms of approvals from third party bodies. For instance, it may not be possible to erect a tied scaffold to the façade of a listed structure due to the risk of façade damage. In these types of cases, early discussion between the Client, permanent works Designer and specialist Temporary Works Designers to understand the constraints and develop a buildable design.

Section 10 Engineering Assurance of Temporary Works

The engineering and architectural assurance process for Buildings, Civils and Architecture is contained in NR/L2/CIV/003, supported by guidance note NR/GN/CIV/003. This guidance has a section four, specific to H&SbD, and makes specific reference to this guidance and other associated H&SbD guidance. (Other disciplines have other assurance standards, as listed in NR/L2/RSE/02009.)

This assurance process applies to all temporary works that meet the following criteria,

- where their presence or failure would affect the safety of the railway,
- where their presence or failure would affect the safety of persons outside the control of the construction organisation.

Temporary works that do not meet these criteria may nevertheless be subject to the assurance process of equivalent organisations, or in-house assurance from within the construction organisation.

NOTE: There are cases on file where temporary works built adjacent to the railway, whose presence was thought not to be able to affect the safety of the railway, still caused events on the railway which have led to harm. For instance, refer to the "Honiton" example in section 14. There should be agreement at early stage, between the PC / PD CEM's and NR DPE/ PE(B&C,) as to what might constitute temporary works where the above bullet points do or do not apply.

NR/L2/CIV/003 requires that all temporary works are checked, with four Design Check Categories (DCC) defined. Guidance on the appropriate DCC for different types of temporary works are provided. Selection of the appropriate DCC is made by the Designer and endorsed or modified as appropriate by the PE (B&C). A Form C submission is required for all temporary works within DCCI, DCCII and DCCIII. The simple Form H is available for temporary works within DCC0.

Particular attention should be given to CIV/003 Section 14 on Temporary works submissions and Section 15 which mandates the elevation of Design Check Categories (DCC) dependent upon the

relationship between the design and construction organisations, and the asset type. Notwithstanding previous comments about the range of organisations preparing designs, it is not uncommon for Temporary Works to be designed by a Contractor's "in-house team" and this may influence the Design Check Category of DCC0, DCCI, DCCII or DCCIII.

Temporary works designs are subject to engineering review by a Network Rail Project Engineer using the DRN process to NR/L2/RSE/02009. It is important that time is allowed in the programme for this assurance process. Traditionally, our industry has delivered Temporary Works designs on a "just in time" basis, placing undue pressures on all parties to sign off an assured design and issue for construction. This should be avoided. Refer also to Section 6 on Focus and Planning.

The Investigation Report into the events at Lockside are a reminder of what can happen if everything is left to the last minute. Refer to section 29.

A single Temporary Works installation may encompass more than one facet of an engineering discipline or competency resulting in the need for more than one design submission. In these circumstances NR/L2/CIV/003 requires the appointment of a Lead Designer, a Lead Checker and an over-arching NR/L2/CIV/003/Form C to define how these interfaces will be managed.

This is best illustrated by an example:

Example

- A scaffold needs to be erected on top of an existing station building
- The railway has 25kV a.c. electrification and the scaffold encroaches within 3m of the Overhead Line Equipment
- The main Contractor employs a scaffolding specialist Contractor to design the scaffolding, however, the scaffolding Designer does not have the expertise to check the loads on the existing building
- So, the main Contractor employs a structural engineer to check the building for the effects of the scaffold loads
- As the scaffold requires electrical bonding a specialist electrical engineer is employed to design the bonding. The electrical engineer should also check that there are suitable electrical clearances.
- Signal sighting may affect the proposed location.

Conclusion

- The Temporary Works installation has four different Designers, a scaffolding Designer, a structural engineer to check the existing building, a signal sighting engineer to check there are no signal sighting issues, and an electrical engineer to design the bonding and check electrical clearances.
- Electrical clearances should always be checked.
- Three separate design submissions are required which need to be integrated.

- The CEM should carry out an inter-disciplinary check (in accordance with NR/L2/RSE/02009) and submit this with the designs, including confirmation of no signal sighting issues.
- A Lead Designer and Lead Checker should be appointed,
- The interface management between the design submissions should be detailed in an over-arching NR/L2/CIV/003/Form C,

Where Temporary Works are required, a Temporary Works Register should be produced by the Contractor and endorsed by the CEM and attached to the Construction Phase Plan (CPP). The temporary works schedule recommended in NR/GN/CIV/003 and in Table 1 of this guide could be used as a basis to develop the register. The Temporary Works Register will usually need to be updated as project progresses. (Also refer to Section 6.2 of BS5975:2019)

The temporary works register could form part of the FormC deliverables, or could be maintained by the CEM and/or DPE out-with the FormC

The DPE/PE should review and agree the Temporary Works Register on behalf of NR. The type of information contained in Temporary Works Register, as a minimum should include;

- Locations/descriptions of Temporary Works & Design Check Categories,
- High or low risk check category for Work Package Planning, determined as defined in NR/L2/OHS/0044, Planning and managing construction work and agreed with CEM and DPE/PE,
- Confirmation of coordination between all permanent and Temporary works has been considered,
- Specify any submissions required for temporary works where there are multiple parties, hence and who is producing the over-arching Form C
- Date of submission to DPE / PE,
- Date of acceptance where required by NR,
- Details of temporary work design organisation,
- Interdisciplinary interfaces including but not limited to track monitoring, pedestrian flow, signal sighting, structure gauging, proximity to electrical systems or consultation with statutory utility companies etc,
- Where NR review is required, the temporary works design should be accepted by the PE prior to submission of the WPP for that element of the works,
- Erection complete and checked, and,
- Permit to Load/Permit to Dismantle.

Where a CRE Civils is not appointed as a Temporary Works Coordinator then CEM should propose a separate TWC using NR/L2/RSE/F0040 in accordance with NR/L2/RSE/02009.

NOTE: Clause 13 of NR/L2/CIV/003 (Temporary Works Operations) applies to Temporary Works whose failure or presence could affect the safety of the railway or the safety of any persons other than those under the control of the construction organisation. Some Temporary Works do not have to follow the full FormC/FormH assurance regime but should nevertheless be designed and provided on the Register.

Section 11 Communication of Temporary Works Requirements and Design Philosophy

It is important that Temporary Works requirements and their design philosophy are communicated across the many interfaces within projects. Examples of such interfaces include:

- Changes of Designer, such as when a PACE Phase 1 (strategic development and project selection) design is taken forward by a different Designer at PACE Phase 2 (Project Design), or PACE Phase 3 (Project Delivery) stages

NOTE; for PACE stages see NR/L2/P3M/201 and other P3M standards.

- Permanent Works Designer(s) and Temporary Works Designer(s)
- Temporary Works Designer(s) and Contractor(s)

If nobody has clear accountability to make sure that the right communications have happened, been demonstrably understood, assumptions have been resolved, and that there are no gaps, there is a clear and potentially very significant risk.

It is essential to appoint someone to have these accountabilities and to be the ***controlling mind***. This may not necessarily be one person but depending on scale and complexity a team of people with the requisite skill and experience to manage the risk and ensure success. Typically, the CEM (supported by the CREs) should be the ***controlling mind.***

Early inclusion (at PACE Phase 1 or 2) of a Pre-Construction Temporary Works Schedule to define the key aspects and requirements, will help discussion during design development of key construction activities, the selection of methods and potential constraints. (Refer to Section 6.) This will lead to the permanent works Designer being more aware of the Temporary Works needs and to support the cascade of information to the Temporary Works Designer.

The CEM has a key role to play in the interface between the Permanent Works Designer and the Temporary Works Designer. IDC should consider the Constructability of the design and treat the construction phase as another interface to be managed. Where appointed early for a design only, but particularly for a D&B contract, the Temporary Works Co-ordinator should attend the IDC along with the respective, appointed, Temporary Works Designers.

The Principal Designer also has clear duties under Construction (Design & Management) Regulations 2015 to plan, manage and monitor the Pre-Construction Phase, to coordinate Health and Safety. The Pre-Construction Phase is defined as any period during which design or preparatory work is carried out for a project, which may continue during construction including the production of Temporary Works designs.

To aid communication between parties:

- Permanent Works designs should include clear drawings with significant hazards highlighted on drawings by means of warning triangles or the like.
- Temporary Works designs should also include clear drawings with significant hazards highlighted on drawings by means of warning triangles or the like.

- Temporary Works Design Risk Assessment information should be clear and relevant to the actual works as opposed to being overly generic.
- Temporary Works Design Philosophy and relevant codes (e.g. limit state vs permissible stress) should be checked against permanent works design and codes when their interface requires it.

Contractual boundaries and communication links across projects should be borne in mind whilst appointing Designers/Contractors for Temporary Works design. Specialist Temporary Works suppliers can often be remote from the day to day project discussions and not included in communication lines. It is therefore important that they receive a detailed brief for their element of the works and be informed of any changes which impact upon this. The PD and CEM can be instrumental in opening these communication lines and the CEM should hold IDC meetings for Temporary Works elements of the project. This will allow the Temporary Works Designer to properly address the impacts of the design on the permanent works.

Regular Constructability reviews (Section 10) should be held by the CEM which will help develop the permanent works design and form the needs of the Temporary Works for the project. The construction interfaces and planning for the Temporary Works needs to be integrated to avoid unnecessary impacts on programme.

Network rail has launched “Our Principles of Good Design” on its public web site at the below link.

Buildings and architecture design guidance - Network Rail

Whilst this document is primarily aimed at good design for permanent works structures many of those principles equally apply to the development of temporary works solutions. This guidance recommends that design of Temporary Works considers these Principles where applicable, in order to improve efficiency.

The link above also provided documents, links and guidance for anyone involved in the design and construction of Network Rail’s built environment.

Section 12 Validation of Design Assumptions / Exclusions

CDM 2015 Regulation 9 states as follows: -

“9.— (1) A designer must not commence work in relation to a project unless satisfied that the client is aware of the duties owed by the client under these Regulations.

(2) When preparing or modifying a design the designer must take into account the general principles of prevention and any pre-construction information to eliminate, so far as is reasonably practicable, foreseeable risks to the health or safety of any person—

(a) carrying out or liable to be affected by construction work;

(b) maintaining or cleaning a structure; or

(c) using a structure designed as a workplace.

(3) If it is not possible to eliminate these risks, the designer must, so far as is reasonably practicable—

(a) take steps to reduce or, if that is not possible, control the risks through the subsequent design process;

(b) provide information about those risks to the principal designer; and

(c) ensure appropriate information is included in the health and safety file.

(4) A designer must take all reasonable steps to provide, with the design, sufficient information about the design, construction or maintenance of the structure, to adequately assist the client, other designers and contractors to comply with their duties under these Regulations."

It is by no means unusual that designs are underpinned by assumptions, particularly at an early stage. This may be for any number of reasons such as lack of survey data or other engineering discipline designs not being fully developed.

Also, a specialist Designer may have excluded an aspect of the overall design from their commission; furthermore, it may not be obvious and not be expected by the main Contractor. For example, a scaffolding structure may need restraint from an existing building and the Designer has noted, perhaps in small print, that fixings are to be validated or designed by others.

It is essential that design assumptions and exclusions are clear and transparent. Incorrect assumptions and/or inappropriate exclusions can each lead to adoption of non-optimal and/or unsafe design solutions. All design assumptions should be validated. Design exclusions should be identified and addressed, as failure to do this may have significant safety implications. The CEM has a key role to play to identify and evaluate the implications of design assumptions and exclusions and implement additional pieces of design as required.

For any project, design needs to be regarded as a single entity even though it may comprise many solutions and involve a significant number of different design organisations involved in permanent and Temporary Works design. The degree of inter-dependency of the individual facets of the design needs to be understood, managed and communicated and the effective fulfilment of the roles of TWC and Principal Designer are vital in this regard.

Key assumptions and requirements of the Temporary Works Design should be clearly communicated to construction workers and in a way that they can easily understand. This could be achieved by:

- Coordination between Designer and Contractor.
- Using principles of prevention e.g. ERIC principles: eliminate, reduce, inform, control.
- Provision of an assumptions register / design log.
- Use warning triangles on drawings for particularly critical items
- Incorporating Temporary Works Design assumptions and requirements (such as hold / check points) on the drawings. This may be via the Pre-Construction Temporary Works Schedule.

- Incorporating Temporary Works Design assumptions and requirements (such as hold / check points) within project specific Work Package Plan(s)
- Preparation of outline Inspection and Test Plans for control of Temporary Work designs. The outline ITP may include hold / check points for inspection. Note that the TWC has responsibility to develop the final ITP for endorsement by the CEM.
- Using a Task Briefing to communicate the Temporary Works Design to construction workers.

It should be stressed to Construction workers that if site conditions change from what has been stated in the Task Briefing, they should inform the Contractor's Responsible Engineer.

Section 13 Construction Sequence as part of the Design

Some designs rely on the construction sequence for the design to be valid. For some designs, the final state of stress used for the permanent works design is very much dependent on the assumed construction sequence.

Changes to construction sequence are routinely reviewed from "practical" construction aspects such as access, possessions, re-scheduling of plant/labour etc. However; changes to construction sequence can have very significant impacts on some designs and may constitute a design change requiring re-design/assessment and acceptance.

In compliance with CDM regulations Designers are required to supply information to both the Principal Designer and the Principal Contractor to indicate the assumptions made in the design about temporary support and sequencing including any significant risks and requirements for Temporary Works. Some of this information will derive from the designer's determination of strength and stability of structures, for example, as these develop through the construction process.

For instance, during the construction of composite steel & concrete beams: -

a) The steel girders may be unstable without temporary bracing during erection,

b) The steel girders may be unstable without temporary bracing (in addition to that required for a) above) during concrete casting before the concrete has hardened and gained strength,

c) The sequence and timing of pouring concrete will dictate the gain of strength (and geometry) of the composite beams which will influence not only the instability risk in (b) but also the strength of beams to resist these and other subsequent loadings. For multiple structurally continuous spans this assessment can be quite involved. The positions, and reasons for, both longitudinal and transverse construction joints need to be clearly illustrated,

d) Loading effects (vertical and horizontal) imparted by temporary formwork and falsework supporting the wet concrete, as well as construction operations live load allowance, can be significant in dealing with b) and c). Contractor's choices of proprietary falsework systems often vary from those assumed at design stage and can impart different loading regimes which need to be checked.

In a similar vein, method-led designs where the construction method has a significant influence on the design, such as bridge installation by launching, sliding or Self-Propelled Modular Transporter (SPMT) require careful consideration. In such cases the support conditions and load paths can change significantly during the construction process. The Permanent Works Designer should work closely with the Temporary Works Designer as well as those responsible for construction to ensure that all critical conditions for the installation are considered.

For further guidance on SPMT see TWf document “SPMTs; a brief guide” ref TWf2022:01.

In all instances, it is essential that clear and concise information is provided to enable the Contractor to understand the design requirements so that they can plan the construction, design Temporary Works and be aware of the implications of any proposed changes. Some other simple examples would include:

- Temporary propping of in-situ concrete beams and slabs,
- Positions of temporary props for bridges envisaged as erected by launching, e.g. balanced cantilever methodology,
- Stability provisions for structural frames for buildings and roofs/canopies, and,
- Temporary support during demolition – refer to Section 29.

Plate 6: Collapse of Gerrards Cross Tunnel during construction.

A train driver at the adjacent station reported that part of the railway had collapsed shortly before he was due to continue his journey through the tunnel. The implications and potential consequences if a train had been under the new tunnel at the time of the collapse could have been catastrophic.

Whilst the Health & Safety Executive (HSE) completed their investigation in early 2015 and have not published a formal report, deviation from the Designer’s intended construction sequence of filling around the reinforced pre-cast concrete arched tunnel units is believed to

have been a contributory factor in the Gerrards Cross Tunnel collapse during its construction in 2005.

The tunnel was constructed of reinforced pre-cast concrete arched tunnel units and the design specified a sequence of filling around the units from the arch unit springing points with the sequence keeping the fill at approximately the same level either side. Photographic and anecdotal evidence suggests that the design sequence was not followed. Refer to Plate 6.

New Civil Engineer magazine 7th July 2005 edition, expressed the opinion that the collapse was triggered by an imbalance in the placement and compaction of the fill, combined with a surcharge of fill over the tunnel crown.

In 2023 a member of the public obtained a draft copy of a HSE report which provides further insight and learning from this event, noting it was a draft and no final report has been published. It indicates that the revised sequencing undertaken was not in accordance with the design and not agreed with the designer, leading to the collapse.

Links to an article in the New Civil Engineer, and the report available on The Railways Archive, is below: -

Series of errors that led to 2005 Tesco tunnel collapse finally revealed | New Civil Engineer

Accident at Gerrards Cross on 30th June 2005: The Railways Archive

It is essential that agreed designs are followed, or any variations to the design are agreed with the designer, who should be given sufficient time to ensure the redesign is properly risk assessed and checked and assured, prior to issuing for construction.

The engineering issues from the above example remain relevant lessons learnt, as is the need to assure competence and compliance with agreed construction methodology & sequencing, rather than vary it without consent. Also see section 14.

Section 14 Changes to Temporary Works

It is by no means unusual to need to change Temporary Works installations as works progress in order to suit programme and site logistics. Changes to Temporary Works may be for such reasons as change of use, revised loadings, partial or phased construction, or removal etc.

It is imperative that Temporary Works designs are properly evaluated, checked, and accepted at all stages by appropriately qualified competent persons.

Ideally the initial design should foresee and take on board all stages of the Temporary Works installation, however, if this is not possible attention and vigilance should be given to changes to Temporary Works.

Any proposed changes to the design on site should be effectively communicated to the Designer for validation prior to execution of the works, with any changes made to the design log.

An example of change causing ill effects is Bridge GE19, where permanent formwork fell onto the live railway following launch and following subsequent site adjustments. See Plate 7 and Plate 8 below.

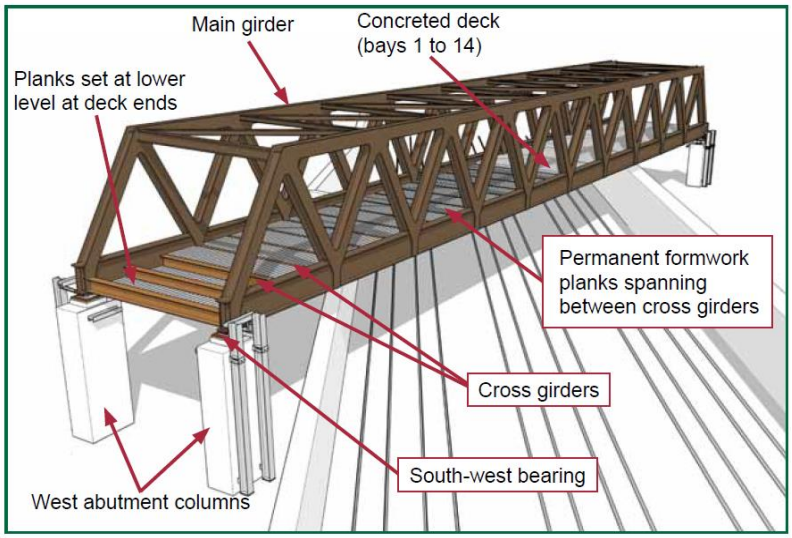


Plate 7 : GE 19 schematic showing main deck components.

Plate 8: GE19 showing failed components having fallen from bridge over.

The immediate cause of the accident was concrete planks falling from the partly completed deck of bridge GE19 onto the track below, triggered by a sudden movement of the bridge deck. Train then hit the debris.

There were many causal factors including (but not limited to) the following: -

a) the inadequate planning and lack of design input to the deck repositioning activity, which resulted in the need to ensure the continued stability of the temporary supports at the east abutment being overlooked;

b) the unauthorised modification of the temporary support by introducing an additional sliding surface, which made the east abutment supports vulnerable to instability due to horizontal force or movement;

There were many contributory factors including (but not limited to) the following: -

a) the lack of accurate or sufficient detail in the steelwork method statement or work plan, which resulted in work outside of the approved documents;

b) the hazard identification process not identifying some low probability high impact hazards (e.g. failure of the *Temporary Works*), which were consequently omitted from the steelwork risk assessment for the post-*launch* phase;

c) the Joint Venture's decision to delegate responsibility for Temporary Works checks to a subcontractor, which meant that they lost visibility of how the structure was performing, or of measures being taken to correct the horizontal movement;

d) the absence of post-work checks, which allowed the unstable condition of the east abutment temporary supports and lack of a secondary means of support to go undetected;

Another example of the consequences of changes to Temporary Works is illustrated in the below incident at Honiton Tunnel in 2022.

Plate 9. Honiton Tunnel Portal washout 21.112022

Changes to access permissions before a looming blockade forced a change in access requirements to the site. Instead of discussing the changes with the temporary works designer it was decided to undertake new temporary works outside the NR boundary to facilitate access, but with no design, no assurance and no designers risk assessment.

The new temporary works restricted a streams flow during heavy rain, which was a known site risk. This led to flooding, which led to a washout of materials onto the live railway. Luckily, trains were stopped before any further incident occurred.

Another example of the consequences of changes to Temporary Works is illustrated in the below incident at Gypsy Patch Lane in November 2020.

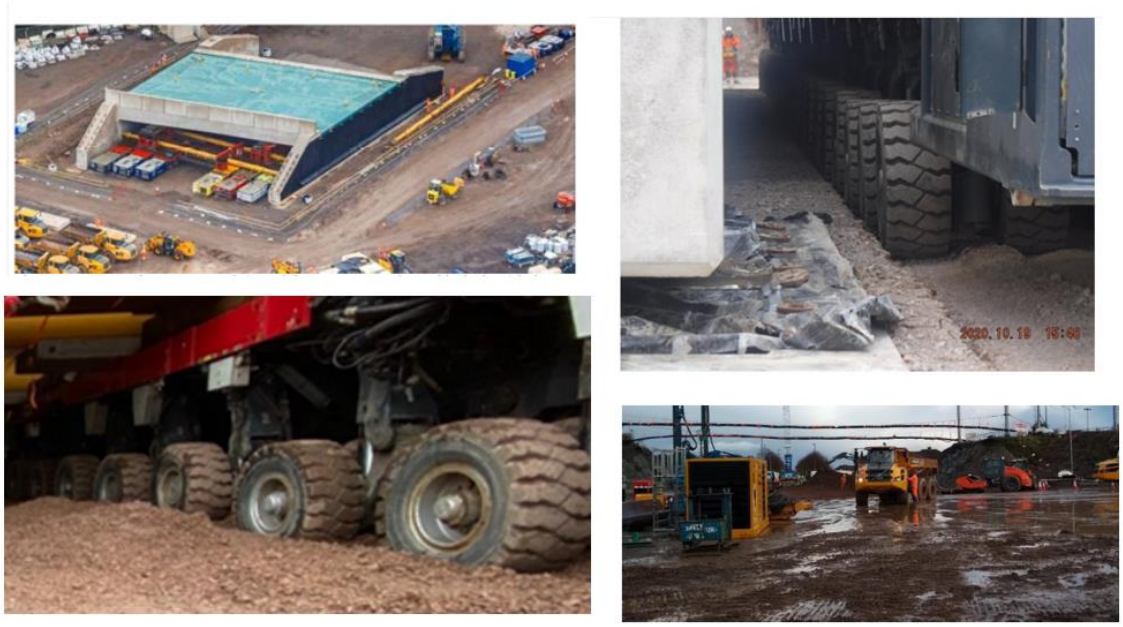


Plate 10. Gypsy Patch Lane mat failure, November 2020.

A haul road / mat design was produced, incorporating H&SbD B&C WG guidance such as provision of warning triangles for key risks,.

However, the mat failed, leading to an entirely preventable 15 day blockade overrun. Points to note: -

- Execution was not in accordance with the design. The design clearly showed the provision of surfacing, which was not installed, and there were many other deficiencies with the installation
- There was ineffective execution and ineffective assurance.
- DRA residual risks were shown on drawings but not followed.
- The fundamental changes to the design were not referred back to designer, hence the designer never had the opportunity to warn the project of the consequences of omitting fundamental aspects of the design. It is essential that changes to AFC designs are referred back to designers for agreement prior to execution of works.

Lessons learnt from this event have contributed to publication of guidance on SPMT moves by the Temporary Works Forum.

Section 15 Collaboration, Teamwork, and Communication

Construction projects can vary from the relatively straightforward to hugely complex. No single person will know solutions to the myriad of challenges that should be overcome to deliver a project safely and successfully. However, the collective skills and expertise of those involved, if correctly harnessed, is a recipe for safety and success.

Working together collaboratively as a project team with regular open and honest communication engenders an atmosphere of mutual support and learning thereby maximising the probability of success. Such collaboration should also include active discussion with the maintainer to ensure that the designs, whether permanent or temporary, do not bring unintended consequences.

Further guidance on collaboration can be found in ISO44001 (Collaborative business relationships).

Some of many exemplars of collaboration, teamwork and communication are shown in the following three examples.

Example 1. River Crumlin underbridge renewal.

Plate 11. River Crumlin. 2021 Civils project of the year.

This project won a Constructing Excellence in Wales award for best practice. A heavily constrained site for the replacement of a heavily skewed underbridge over water demanded the integration of temporary works and permanent works, whereby the permanent works designers refined the permanent works design to suit the temporary works designers constraints, enabling the execution of works whilst allowing traffic flows, avoiding a 40 mile diversion to road users. Collaboration between the team and with stakeholders enabled this efficient, safe project.

Example 2; Ravenscraig new RC underbridge & SPMT move.

Plate 12. Ravenscraig Bridge SPMT move, 2023

This project is another exemplar of collaborative working, with the integration of permanent works and temporary works requirements using collaboration between all parties to the project. It took lessons learnt from other SPMT moves, with fully integrated and assured designs, attention to good site quality control, and effective planning from the outset.

Example 3; Bletchley Flyover, for East West Rail.

Plate 13. Bletchley Flyover.

Engineers saved £70M, reduced disruption and sped up construction by using creative construction techniques, integrating permanent works with temporary works, to build a new railway viaduct over the West Coast Mail Line at Bletchley, for East West Rail, using H&SbD Principles, with examples including: -

- *Using* Modern Methods of construction,
- *Us*ing hollow PCC as "formwork"
- *Integrat*ion of temporary works and permanent works designs at all stages of sequencing.
- *Us*ing PWorks to create a physical barrier allowing further construction with trains running, to create safe segregation

This is an exemplar of the collaborative approach needed between all parties to enable a safe, efficient design. It shows how construction engineering teams can effect changes to the construction methodology that can offer safety / economic benefits.

Section 16 Competence and Expertise

Working within the railway environment requires knowledge of the constraints when carrying out designs that interface with a live railway.

It is the duty of professionals to understand the limits of their competence and seek advice when needed. Making the best use of available resources can enhance their own knowledge and enhance their technical support network. Competence of individuals should be assessed by a competent person, using a suitable competence framework.

Industry research has identified significant changes since the 1970's in the way the construction industry deals with Temporary Works and particularly its design. A reduction in the number of Contractors' in-house Temporary Works departments and the increased usage of proprietary systems has led to more responsibilities being with specialist Contractor/suppliers and to problems associated with lengthy supply chains where, quite commonly, design and erection responsibilities are divided. The roles of Temporary Works Coordinator (TWC), Principal Designer and Contractor's Engineering Manager (CEM) need to recognise the risks of multi-tiered Temporary Works design and ensure that the transfer of information is seamless, and that there are no gaps.

Specialist Temporary Works Designers / engineers may not have detailed knowledge of the railway. For this reason, it is important that a railway specialist provides a bespoke design brief. The brief can be created by someone (or a team of people) who have a detailed understanding of the constraints involved and are able to convey railway specific hazards. The CEM should own this.

In all cases Engineers/Designers CVs should be sought at an early stage to enable verification of knowledge and expertise that exists within the proposed team. In the case of nominating a Contractor's Responsible Engineer (CRE) and CEM, knowledge of the railway, the design process, and a good understanding of the engineering issues to be addressed should be evident when reviewing their CV's. Preferably, information will be presented to support the competency process outlined in NR/L2/RSE/02009

Further to the consideration of competence of individuals, the competence and in particular, relevant organisational capability, of the Design Organisation should be reviewed. Individual CVs yield a certain amount of information but the Design Organisation responsible for Constructability / Temporary Works design should be able to demonstrate experience of projects of similar size and complexity. For example, previous experience in basic scaffold design would not necessarily be sufficient for a complex scaffold bridging scheme. Apart from a direct approach for any given project, access to information via the RISQS system should be of assistance in this review.

Time taken at this stage in selecting Suitably Qualified and Experienced Persons (SQEP) and the right organisation will result in quicker and better quality approvals and better turnaround of engineering deliverables (such as FormA, FormB or FormC, as defined in NR/L2/CIV/003 'Engineering and Architectural Assurance of Building and Civil Engineering Works') and Work Package Plans (WPPs), following NR/L2/OHS/0044 'Planning and Managing Construction Work'.

It is also important to ensure that there is adequate Principal Contractor (PC) supervision of the works using SQEP, including a suitable level of independent monitoring where necessary, also by SQEP. Supervisors should be experienced in working in the particular confines of the Railway, or in turn supervised by those who are.

The competence of NR staff is covered by NR/L2/CIV/1000; Competence Management for Buildings and Civils Infrastructure, and its various modules. For instance NR PE (B&C) staff, and others undertaking NR PE (B&C) roles, are covered by the requirements of module NR/L2/CIV/1000/06; Competence Management for Assurance and Design of Buildings and Civils Infrastructure.

Also see competence requirements for other NR and non NR engineering assurance roles in NR/L2/RSE/02009 e.g. DPE/CEM/CRE/DEM.

Section 17 Early Contractor Involvement

Early Contractor involvement can take on many forms ranging from informal discussion with industry colleagues/contacts within the contracting sector to formal alliances.

Construction (Design & Management) Regulations (CDM) and guidance LSE L153 states: -

> *"…139. The Principal Contractor must liaise with the Principal Designer for the duration of the project. The early appointment of a Principal Contractor by the client will allow their construction expertise to be used from the earliest stages of designing and planning a project. They should also liaise with the Principal Designer throughout the construction phase on matters such as changes to the designs and the implications these changes may have for managing the health and safety risks…".*

It is essential that the Constructability of designs is understood by Designers for designs to be robust. Designers do not always necessarily understand Constructability of their designs, and this is particularly true in a railway environment where access and logistics have significant impacts.

Understanding the constraints faced by Contractors may lead to the Designer amending their design to facilitate Constructability, hence Designers are encouraged to seek Contractor advice where appropriate. Whilst some projects are relatively straightforward, understanding the Constructability issues and phasing of complex projects can have significant effects on designs.

Improved Constructability has significant advantages which may include improved safety, programme, and cost, and reduced Temporary Works.

There is a range of benefits that may be gained by participating in Early Contractor Involvement (ECI), including:

- Early creation of delivery team with partnership approach and team ethos based on long-term relationships
- More scope for innovation to offer better value & selection of suppliers based on best value
- Improved risk management
- Buildable design accounting for best practice

This would likely include the employer, Designer, specialist Contractors and main Contractors working collaboratively. For this process to be successful it is important to:

- Involve the Contractors early, but not so early that time is wasted because the project detail is not sufficiently developed for meaningful analysis. This should include ECI at Option Selection stage in appropriate circumstances.
- Clarify scope to eliminate gaps and understand the interfaces.
- Develop a design programme such that, at its completion, a contract can be signed between the parties in sufficient time for the benefits to be fully realised.
- Consider any possible conflict of interest between the parties.
- Ensure a Contracts and Procurement strategy is developed and executed by the Client which accords with the above where possible,
- Formalise the outputs required from ECI such that there is assurance around the early development.

Also see section 6 on focus and planning regarding ECI.

Section 18 Constructability Reviews

A designer's ability to influence safety is considered by some researchers to be greatest in the earliest stages of a project.

Designers should undertake Constructability reviews at various stages of a project. The chosen stages may vary to suit complexity, design development, or changes to access or site conditions. Attendance at Constructability reviews should not be limited to the design team and the involvement of Contractors and/or other independent construction professionals or peers is encouraged.

As a minimum, Constructability reviews are suggested at the following stages as appropriate:

- Feasibility
- Option Selection
- In support of Approval in Principle
- Commencement of detailed design (if the ownership of the design has changed)
- Completion of detailed design
- Commencement of construction
- When changes occur, e.g. access, design, significant resources etc.

The agenda or check list for reviews can be tailored to suit a project, however, on railway projects the following topics should be considered for inclusion:

- Possession availability and Isolation availability
- Operational requirements
- Physical features of site, e.g. topography and ground conditions.
- Physical access
- Transportation and storage of materials
- Environmental and Social Value issues including noise, fumes, impact on neighbours and communities etc.
- Other projects in the vicinity of the site
- Condition of existing infrastructure.
- Changes from previous reviews

Constructability reviews will highlight issues which may affect safety, operations, Temporary Works requirements etc. and will inform Designer Risk Assessments. This may also include possession availability and design change.

Constructability reviews should also consider the likely impact on railway neighbours and test whether the proposals have the potential to disadvantage particular groups in the community. Diversity Impact Assessments (DIAs) are a useful tool to ensure that designs are inclusive. Also see NR/GN/CIV/300/04 Inclusive Design Compliance, NR/GN/CIV/300/07 DIA guidance and NR/L2/OHS/00135 DIAs.

Use should be made of NR Construction Managers at early stages in the design process to add value through local knowledge of the Railway.

Construction reviews without construction teams in the room may deliver minimum benefit. See section 17 on ECI and section 6 on focus and planning.

An example of a constructability review agenda is included in **Appendix A**.

Section 19 Scaffolding

Network Rail does not have any specific standards for scaffolding design but rely upon National Access and Scaffolding Confederation (NASC) industry and British standards. At time of this guidance preparation the key documents are:

- BS 5975:2019 for Temporary Works procedures and the permissible stress design of falsework *(NOTE; Due to be updated in 2024)*
- BS EN 12810-1:2003 Façade scaffolds made of prefabricated components - products specifications
- BS EN 12811-1:2003 Temporary works equipment: Scaffolds - Performance requirements and general design
- NASC TG20:21 Technical Guidance on the use of BS EN 12811-1

For the erection and construction of scaffolding guidance is taken from NASC SG4:22 Preventing falls in scaffolding operations

Within the railway environment there are many considerations that influence the design and construction of scaffolding access, protection and shoring. Equally, selection of the most appropriate scaffolding solution may also be heavily influenced by the environment within the railway infrastructure. Examples of this may be on stations, where CD/RA buttons become inaccessible to staff once a façade scaffold has been erected, or signal sighting is disrupted due to scaffold erection around an overbridge wingwall/abutment. It is key that a competent CRE with railway experience reviews the design to check that all interfaces are captured.

Apart from the environment, two key determining factors affecting the type of scaffold forms of design and construction are:

- the time period over which the scaffold is to remain in position/use
- the nature of loading to be applied

Scaffolding of a short duration usage will invariably involve the use of standard component parts and should be assessed as rigorously as a scaffold that may have a much longer period of installation. The design of scaffolding erected for short term use is often neglected and the normal engineering assurance processes not undertaken. Design checks and care in construction should be taken for all installations.

The nature of loading applied to scaffolds can vary from light duty access to substantial storage. Scaffolds with heavier loading demand more care in design and construction since factors of safety can become eroded leaving a higher residual risk when in use. This risk not only relates to the operatives using the structure but also the railway environment with potential collapse being the ultimate critical case.

When working close to OLE and other exposed live electrical equipment the use of GRP or other non-conducting materials are necessary. Design of bonding will be required for metallic items in some situations adjacent to OLE areas. Advice of the E&P Project Engineer should always be sought.

Working clearances and gauge requirements of rolling stock, signal sighting clearances, OLE clearances, protection against dropped materials, safe access, egress, and movement of materials are also a key part in the specification for scaffold performance criteria.

Beware of uncontrolled use of sheeting on scaffolds which have not been designed, especially where sequencing of works to surrounding areas may change live loading. Scaffolds are light structures sensitive to lateral loads and instability due to wind is very important. Also ties and bracing are important elements which should be designed and installed correctly. In plate 14, the scaffold was erected in a sheltered location and some designed ties were not installed. Following a nearby demolition, the environment changed, and the scaffold became exposed to wind.

Notwithstanding ensuring that “standard” scaffolds are appropriately founded and laterally restrained, “standard” scaffolds should be relatively straightforward. However, care should be given to the design of bespoke scaffolds particularly with respect to connections and overall stability. Care should be taken when mixing proprietary and bespoke temporary works items, which may be designed on a different basis.

Two examples of scaffolding failures and lessons learnt are below: -

Plate 14: London Bridge Scaffold overturn 28.1.2015

On this site adjacent demolition work was undertaken which exposed the scaffolding structure to external wind forces which it was not designed for, leading to collapse. It is vital that Temporary Works activities are coordinated with Temporary Works designed for all loading conditions foreseeable during the lifespan of those Temporary Works.

Plate 15: Warrington Scaffold bridge failure MAJ1,

On 08.08.21 the incomplete scaffold service/footbridge adjacent to a bridge in Warrington partially collapsed. At the time of the collapse, scaffold operatives were working on the structure, carrying out the completion of the structure (which included installation of scaffold boards and bracing). Upon collapse, the scaffold fell towards the existing Bewsey Street railway bridge and came to rest on the parapets. Two scaffold operatives, who had been working on the structure, egressed the structure during the collapse. A third scaffold operative, positioned on the towers, exited via the staircase. No injuries were sustained. There was a litany of issues with the design and execution of this structure, including the following; -

- *Failure of scaffold* members due to loads imposed beyond the structures capacity at time of collapse,
- *Inadequate design and application of design assurance*,
- *Inadequate communication of key design risks*,
- *Programme inaccuracy,*
- *Inadequate construction and application of construction assurance*,
- *Ineffective hazard/risk identification and mitigati*on through optioneering,
- *Operations/management disconnects*,
- *The structure was incomplete when the decision was made to load it. There was no permit to load*,
- *The F005 was only signed regarding passage of trains, not that the structure has been constructed i*n accordance with the design.
- *There was inadequate time given to* design, check, assure and execute the works safely.

*Key l*esson learnt is to allow sufficient time for design, checking, assurance and execution of the works, following engineering assurance requirements of NR/L2/RSE/02009 & NR/L2/CIV/003, and this guidance.

Also see example in section 6 of matters to consider for IDC/IDR on a station concourse.

Also see **Appendix F** for an example of the need to ensure that existing structures can support temporary works such as scaffolding.

Section 20 Piling Rig / Crane Working Platforms

The requirements for Piling, Drilling, Crane, MEWP and SMPT operations adjacent to the Railway are set out in NR/L3/CIV/0063. Particular attention is drawn to Section 8 which sets out the requirements for management of the working platform. A properly designed and maintained piling / crane platform is a crucial element of Temporary Works and is key to managing risk associated with these works.

The design of the temporary working platforms should be assured in accordance with NR/L2/CIV/003 and NR/L3/CIV/0063.

In 2003 a piling rig collapsed onto the London Tilbury Southend lines. See plate 16. In order to remove an obstruction, the construction companies dug a trench in the piling platform, which damaged a critical geotextile membrane. The trench was then poorly backfilled. When the rig crossed the trench, the ground settled under one side causing the piling rig to overturn across the live railway lines, bringing down 25kV a.c. electrified lines. A passenger train had passed some 2 minutes earlier. Fortunately, there were no injuries, however, the railway line was closed for 3 days. The subsequent investigation found that a significant contributing factor was the breakdown of communication between senior and junior site managers, who were not aware how critical the piling platform and design was, or the need to involve the platform Designer in any repairs.

Plate 16: LTS line crane failure due to inadequate foundations.

Network Rail recognises that in certain circumstances piling and crane operation restrictions can result in seemingly onerous working practices. In such circumstance's consultation and agreement of additional mitigation measures with Network Rail may lead to less onerous working practices. Additional mitigation measures may include establishing a more robustly designed piling platform.

Plate 17: Good practice. New Southgate.

An example of good practice, where piled foundations and a flat platform were needed to serve a CFA piling rig for an adjacent development, resulting in a temporary works design to avoid surcharging an existing retaining structure adjacent to the railway. Good practice included early topographical, ground and wall condition surveys and sufficient time to develop the design and gain all necessary approvals.

Further guidance on working platform design is given in **Appendix C** from TWf. See "Working Platforms: Design of granular working platforms for construction plant - A guide to good practice" ref 2019;02 and TWf "Assessment and management of outrigger loading" ref TWf20022;002.

Section 21 Hoardings

Hoardings and protection to / from active work is required at all interfaces between construction and non-construction/project personnel. Hoardings have the dual purpose of providing a barrier that protects construction operatives from potential danger such as live OLE, third rail and moving rolling stock and non-construction/project personnel from injury or harm from construction activities. Specifications for hoarding and protection barriers can be found in British and Network Rail standards.

In addition, detailed and useful design guidance can be found in a document produced by the Temporary Works Forum (TWf) ref: Hoardings; a Guide to Good Practice TWf2012: 01 (revised August 2020.) This now included some railway references, such as clause 4.2.6 for indirect loads from passing trains with reference to UIC Code 779-1. However, this does not include railway specific requirements covered by NR and RSSB standards such as for minimum platform widths.

Typical key issues for design are:

- Fire and flame spread properties,
- Impact and crowd loading,
- Environmental wind loading,
- Dynamic train pressures,
- Loading from mobile plant/station platform equipment,
- Protection against materials from being thrown over a barrier/hoarding,

- Ensuring that electrical and rail vehicle gauge clearance is not compromised, *
- Ensuring that signals are not obscured, *
- Ensuring that sight lines for train despatch staff are not impeded from all locations where despatch staff are located during despatch, *
- Ensuring that operational equipment remains accessible, *
- Ensuring that hoardings do not prevent access for maintenance, *
- Ensuring that pedestrian flows are safe. It may be necessary to carry out pedestrian flow modelling to validate the effect of building a hoarding, this is particularly an issue when working in and around railway stations. When hoardings affect circulation of people it is worth considering trialling the new layout in advance under controlled conditions in order to fully understand the impacts. This may be done by using tape or easily removable barriers, and observation, particularly at peak times, and is a good way of confirming pedestrian flow predictions, *
- Checking that any equipment to be fixed to hoardings post erection does not affect clearances and/or pedestrian flow,
- When working on stations hoarding proposals require the agreement of TOCs and/or the Network Rail major station management team. *

Note. - Those items marked with an asterisk should be deemed to be also covered in more detail by the usual IDC/IDR process. It is anticipated that Temporary Works Designers should be sufficiently aware of the issues associated with these items such they might be marked as 'Hazards' on the Temporary Works drawings, to flag up the need for input required from the relevant design disciplines.

Refer also to Section 26.

Section 22 Protection Decks and Dropped Loads

In areas of work where construction activities are to be carried out over a live railway or station, whilst maintaining 'business as usual' operations, a protective/working barrier/deck may need to be installed. The functionality of this barrier can change throughout the duration of any works. Initially the barrier may be in place to provide safe/working access above the railway; as the work progresses the barrier may be required to act as a weatherproof layer (i.e. a roof) and may also be required to either support additional access equipment/plant or to be able to sustain an impact force from falling material, equipment or debris.

Early understanding of the full functionality of the proposed protection/working deck is essential if an effective and safe system of work is to be established for all aspects of the work to be undertaken.

Plates 18 to 21 provide details of two separate incidents where the protection arrangements proved to be inadequate risking injury to those below.

Plate18: Protection Deck Penetrated by Dropped Loads.

Two metal rod handrails were dropped whilst removing them during a station re-roofing project. The rods penetrated the access deck and landed in the station below. The station was operational. There were no injuries however the safety implications were very significant. The incident led to a review of the protection deck design and working practices with associated delay and disruption to the project.

Plate19: Operational Station with Suspended Protection Deck.

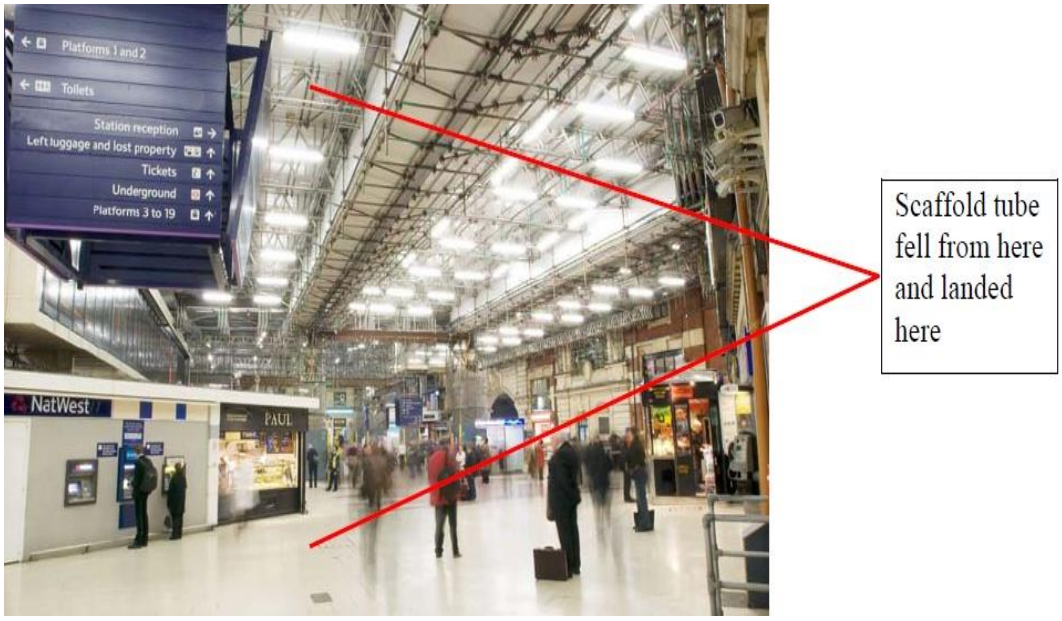


Plate20: Station roofing works.

During a station re-roofing project, a scaffold tube fell from here to here through a gap in the protection deck (see Plate 21 below). The tube narrowly missed a 9-year-old boy, then rebounded and struck a 6-year-old girl

Plate 21: Clear gap in protection deck caused safety incident

A key issue in the Victoria scaffold dropped pole incident was the mix of a system scaffold with tube and fitting scaffold components. The system scaffold had a gap in the boarding large enough for a loose tube to pass through. Care should always be exercised when mixing system scaffolds with tube and fitting scaffolds as the two are not always compatible and often force a situation where the manufacturer's instructions for system scaffold may no longer

apply. In these situations, a design should then always be undertaken encompassing the whole structure.

The specification for the performance of the access/protection deck should consider:

- Blanket live load
- Concentrated live load
- Equipment and materials storage loading
- Impact loading from landing equipment and materials
- Impact loading from falling equipment and materials (dropped loads)
- Physically impervious barrier, i.e. absolutely no gaps.
- Water impervious barrier
- Sound impervious barrier
- Fire protection barrier
- Smoke and environmental control barrier
- Ventilation of fumes (e.g.: diesel trains)

Designing/analysing a deck/barrier for dropped loads can be very complex as the weight and shape of objects and the height from which they can fall can all vary significantly. It is necessary to analyse and understand the range of activities which can lead to dropped loads.

It may be appropriate to carry out trials of the deck construction by dropping loads onto it in order to arrive at a design. Part of the issue is in determining the impact area of the dropped load. This is often difficult to calculate, especially with irregular shaped objects. In fact, such drop tests are perhaps the best way of proving the adequacy of the deck and structure and are also the best way of providing assurance of the system to all parties concerned.

Mitigation measures such as producing a load management plan or tethering of materials can be used to mitigate risk. It may be that it is not practical to design a protection deck for the full range of loads it may encounter and that certain activities need to be carried out with no operations or personnel below the protection deck. Such limitations should be clearly communicated.

Incorporating all or a combination of some of the above design criteria may lead to conflict of requirements, resulting in a compromise between differing aspects of the design. The decisions as to the better way forward may rest with other constraints, rather than just with impact loading.

Section 23 Earthing and Bonding of Metallic Structures / Elements on a.c. and d.c. Electrified Lines

Earthing and bonding requirements for temporary (and permanent) metallic structures are frequently missed by Designers. When undertaking earthing and bonding on electrified lines the following should apply: -

25kV a.c. Overhead Line Equipment

At all times when working within the boundary fence of an electrified railway equipped with 25kV a.c. overhead line equipment, the requirements of NR/L3/ELP/29987 Working On or about 25kV a.c. Electrified Lines should apply

The requirements for the design of earthing and bonding systems for 25kV a.c. electrified lines are described in NR/SP/ELP/21085.

Bonding is required to ensure a return path that is rated for traction currents and fault currents, and to provide a system that limits permissible effective touch voltages and/or rise of earth potential (earth potential rise) voltages to acceptable levels

Exposed metal parts of structures and other extraneous metalwork that are within the overhead contact line zone (OCLZ) or current collector zone (CCZ) must be bonded to the traction return system. The dimensions of the OCLZ and CCZ are provided in NR/L2/ELP/21085.

Bonding is not required for metal structures that are located outside the OCLZ and or CCZ. Provisions such as bonding or insulating sections may be required if the metal structure is in excess of 1 km in length and parallel to the railway even if the structure is outside the OCLZ and or CCZ.

Temporary metal structures, such as scaffolding, should where possible, be located outside the OCLZ and or CCZ. It is unlikely that a temporary structure, such as scaffolding, will be in excess of 1 km in length.

Where the bonding of a metal structure is required, it should be made with one bonding connection only between the metal structure and the traction return circuit. The point of connection with the traction return circuit should be agreed with Network Rail's representative, who may in-turn need to consult with the Route or Regional Engineer (E&P).

d.c. 3rd and 4th Rail

At all times when working within the boundary fence of an electrified railway equipped with conductor rail(s), including both 3rd and 4th rail systems, the requirements of NR/L3/MTC/EP0152 - Working on or adjacent to conductor rail should apply

It should be noted that bonding requirements for d.c. 3rd and 4th rail lines are significantly different to those on a.c. lines, the principle being such that structures and extraneous metalwork should remain insulated from and not be connected to the negative return current path. Specialist advice for bonding arrangements in d.c. 3rd and 4th rail areas should always be sought. NR/SP/ELP/27192: - Design and Installation of Negative Bonding and Associated Equipment on

the High current d.c. Electrified Lines (formerly RT/E/S/27192) may be used for reference purposes, but this standard primarily deals with the requirement for rail bonding and maintaining the continuity of the negative return current path.

d.c. Overhead Line Equipment

Sheffield Tram Train and Sunderland Metro infrastructure is equipped with d.c. overhead line equipment, the bonding requirements for which are again significantly different to those in a.c. electrified areas. When working in these areas' specialist advice should always be sought.

Lightning protection and temporary works building services

This guidance does not cover the many situations where consideration needs to be given to the earthing and bonding of temporary structures such as in situations where there is an interface with existing lightning protection systems on structures/buildings, or whether a scaffolding needs its own lightning protection system. Specialist advise should be sought.

Temporary structures such as temporary lift installations will have requirements for earthing and bonding. Specialist advise should be sought.

Section 24. Gauging and Electrical Clearances

In areas without OLE the Contractor should design, construct and maintain all Temporary Works to provide minimum clearances as defined in Network Rail Company Standard NR/L2/TRK/2049 as amended by specific project Requirements and NR/L3/TRK/2047/Mod07, regarding G1.1a Standard Structure Gauge and G1.1b Temporary Works Structure gauge.

The Design of a structure carrying or passing over electrified lines must comply with **NR/L2/ELP/27716** – Electrical & Mechanical Clearances. (Due to be published December 2023.)

Gauging is the activity of demonstrating compatibility between train & train and between train and infrastructure; to ensure that sufficient space exists around a moving train (clearance) to provide safe operation.

The prime requirement is that there are always positive clearances between rolling stock and rolling stock or rolling stock and infrastructure. To ensure adequate clearances are provided, the following must apply: -

a) Assets should be installed in the area available for all infrastructure (see GI/RT7073 Appendix A), and

b) A minimum clearance between the swept envelope / gauge of a vehicle and the infrastructure and / or swept envelope / gauge of a vehicle on an adjacent track should be calculated.

All structures within the major and minor structure gauges as specified in NR/L2/TRK/3203 should be surveyed and recorded in the National Gauging Database (NGD). Network Rail requires clearances should be approved by a person with the adequate delegated gauging authority.

The Contractor must be satisfied and satisfy the employer's representative that; -

c) all Temporary Works are correctly designed for the expected loading conditions and that

d) all gauging requirements are fully satisfied whenever track is open to traffic with Temporary Works in place. This includes the envelope above any train and especially the electrical clearance to the pantograph horns in 25kV areas.'

Standards include, but are not limited to:

- **GI/RT7073**: Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances
- **GI/RT7020**: GB Requirements for Platform Height, Platform Offset and Platform Width
- **GM/RT2173**: Requirements for the Size of Vehicles and Position of Equipment
- **RIS-7016-INS**: Interface between Station Platforms, Track and Trains
- **NR/TRK/L2/3201**: Management of Tight Clearances and Track Position
- **NR/TRK/L2/3203**: Structure Gauge Recording
- **NR/L3/SIG/11303/2G05** Signalling Installation - Locations: Construction
- **NR/L3/SIG10064 issue 7**: NR/GI/C001 Clearances for S&T Equipment
- **NR/L3/TRK/2049/mod07**: G.1.1a Standard Structure Gauge
- **NR/L2/ELP/27716:** Electrical & Mechanical Clearances. (Due to be published December 2023)
- **NR/L3/TRK/2049/mod05**: E.1.1: Electrical Clearances - 25 kV

NOTE; As of the date pf publication of this guidance (November 2023) the above standard module NR/L3/TRK/2049/ mod05 E.1.1 must not be used, which has an agreed Variation Pending Standards Change (TR45287 02/09/2017) to withdraw the clause.

Whilst Temporary Works design might show correct clearances to track, OLE etc. there is always the risk that items such as built scaffolds or tunnel sweeps/laggings do not comply due to isolated elements breaching theses clearances (typically ledgers and bracing members.) On site focus and check of this is required by the CREc.

Examples of lack of compliance with the above are illustrated in Plates 22 to 24 below:

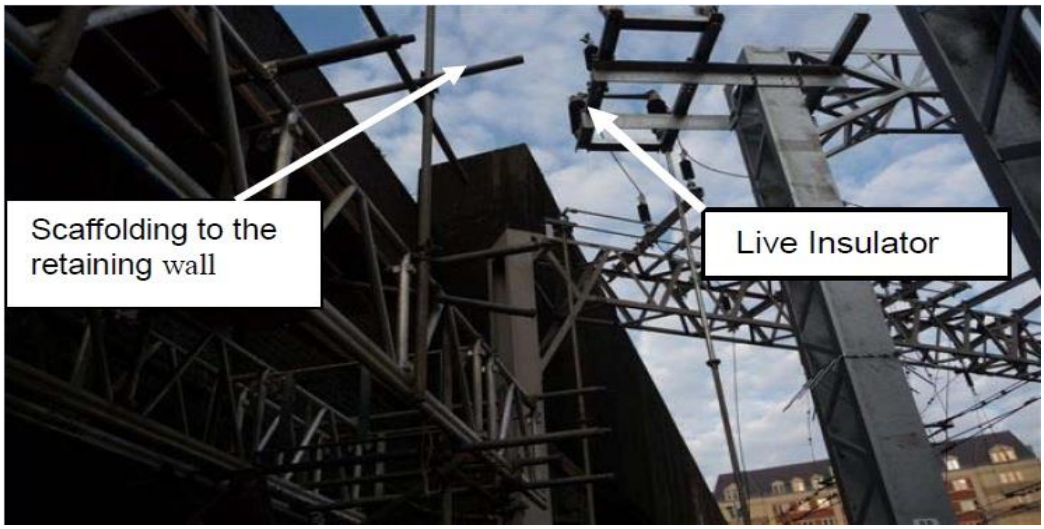


Plate 22: Scaffold constructed within 500mm of live overhead line equipment. Remedial works led to delay and disruption

Plate 23: Scaffold constructed within the structural gauge, causing damage to train.

Plate 24: Temporary works in tunnel struck by train.

On 27 February 2016 an engineering train struck a supporting strap fixed to the side wall of Meir Tunnel. The strap had formed part of a 'sweeps and tees' which are Temporary Works for a repair. The design had not been constructed within design limitations on the associated standard drawing and had not been checked for gauging contrary to the notes on that drawing.

Section 25 Safe Loading, Lifting, and Transportation

The incident at Pouparts in December 2010 (see Plate 25) magnified the need to ensure that hazard information relating to the load characteristics of building components is adequately communicated.

Designers should consider the viability of safely loading, lifting, and transporting components during the permanent works design process and highlight any requirements or unusual characteristics such as eccentric or unusual centre of gravity of components, acceptable lifting points etc. Where components require lifting, it would be good practice for the Permanent Works Designer to design the lifting points and detail any out of balance which could occur to the loads in transportation/temporary state. Temporary Works Designers should detail any propping, stillages or any method related lifting required and should take guidance from the Permanent Works Designer in regard to the constraints for the particular component.

Access constraints should be considered at early design stages, as such constraints might dictate construction methodology which might constrain design. For instance, steel connections can be designed to suit maximum transport lengths and there may be access constraints during transportation to consider. If access cannot be made to remove areas KIROW cranes might be

needed, with associated limits on lifting weights which might affect designs. Consideration could be given to Construction Logistics and Community Safety (CLOCS) or similar schemes to maximise construction safety.

Plate 25: Pouparts

Bridge component following uncontrolled rotational movement due to out of balance forces, causing serious crushing injury.

Contractors should ensure that effective communication and coordination is in place between the various parties involved in transporting components from their place of manufacture to their final location. The responsibility for the design of all lifts and jacking operations should be clearly defined.

Section 26 Use and misuse of proprietary products

Proprietary products typically come with instructions and parameters for their general use. Should such products be used in a way that they are operating outside their design parameters, there is a risk of failure.

Conditions that are unique to a railway environment should be fully evaluated. The consequences of failure in a railway environment will also demand a more exhaustive evaluation of the suitability of a proprietary product.

Proprietary products and standard designs should not be used outside their design parameters. If they are to be used in this way they should be properly designed and checked.

In addition to stability issues, the use of proprietary products should also consider clearances to the railway and leave sufficient space for regular lineside activities.

One example is the use and occasional misuse of open mesh type fencing such as Heras and other free-standing barriers.

There are several stability options available however the “base” model is designed as *open* mesh fence.

It should be noted that ‘open’ Heras fencing can be difficult to justify for typical wind loading. This is borne out by observation of such fallen fences.

If open mesh fences are covered in debris netting and/or signage, they may be blown over in strong winds unless they have been designed and specified as being covered in netting etc.

Loading that is unique to the railway environment isn’t fully considered in industry guides such as TWF’s “Hoardings – A Guide to Good Practice” and should be factored into Temporary Works designs. For example, aerodynamic loading from passing trains may need to be considered. Fencing on platforms may need to be designed to withstand crowd loading, etc. Load information may need to be taken from other railway design standards.

Heras and other reputable suppliers will issue sensible advice on wind loading, other lateral loading and suggest the type of support that should be used. Outside of the railway environment, ground spikes can be used but present increased risk in rail environment (due to buried service strikes) and appropriately designed kentledge footings may be more appropriate to remove risk of overturning. Where this produces a fence with an unacceptably wide footprint, the fence may have to be fixed to posts concreted into the ground or tied to an adjacent structure.

The Temporary Works Designer may have to consider the risk associated with the actual location of any such fence. A small compound at the end of a car park, for example, would be less onerous than a fence used on a platform adjacent to the track. By risk assessment it might be judged that the standard base design for a simple Heras fence requires additional kentledge or fixing down for certain locations.

The same philosophy should be applied to any proprietary product where the risks associated with failure are significant. Refer also to Section 21.

Section 27 Risk of Asset Instability due to Temporary Excavations

The risk of asset instability due to temporary excavations during execution of works requires careful consideration and should be explicitly addressed during the design and Designer risk assessment process, Construction Phase Health and Safety Plan, Work Package Plans and Task Briefings for all applicable projects.

When assessing the risk, the Designer will need to consider several factors, including:

- Existing asset information, including desk study, recent examination and assessment records, and any records of historic asset instability
- Ground Investigation information, including soil strength, stratigraphy, and ground water conditions
- The permanent and variable actions

- The location, orientation, depth and extent of the excavation relative to the existing asset (such as earthwork, structure, track, electrification, telecommunications and signalling equipment)
- The limits of how long the excavations will be left open prior to being backfilled
- External factors, such as the potential for inclement wet weather during excavation works.
- All temporary earthwork slopes require a geotechnical design (under CDM anyone specifying an angle of repose is a Designer)

Where the design and Designer Risk Assessment process does not identify the requirement for a formal Temporary Works Design then any construction methodology constraints deemed necessary by the Designer are to be defined in the detailed design and check process for permanent works.

The design and Designer risk assessment process should consider the required supervision levels and monitoring regime during (and following) the excavation works.

The assessed risk of earthwork instability during excavation works should be reviewed if site conditions change from that stated in the design. In such cases the Contractor's Responsible Engineer / Temporary Works Coordinator and the Designer should review methodology and if appropriate propose an alternative Temporary Works design.

Examples of lack of compliance with the above are illustrated in plates 26 to 28 below:

Plate 26: OXD39 Wingwall Failure due to undermining of existing structure during Temporary Works excavations.

The foundations to an existing wingwall had been destabilised due to the construction of new foundations adjacent. The effects of the proposed foundation construction on the existing infrastructure has been inadequately considered.

Plate 27: Stafford trench collapse due to no temporary shoring.

This was a 2.4m high excavation in unstable ground with no shoring design or execution. It has vertical faces; the plate showing the scene after partial collapse part buried an operative, who was seriously injured.

Plate 28: Breich, Scotland. Very poor Temporary Works with no design.

This is an example of very poor practice, with no design & inadequate construction, not fit for purpose and introducing to the site a number of significant health and safety hazards.

Section 28 Temporary works affecting track geometry

Temporary works either within the Track Support Zone (TSZ,) [see definition within NR/L2/CIV/177,] or affecting the stability of the TSZ have the potential to cause changes to track geometry leading to train derailments such as at Cricklewood in January 2006 (see plate 29).

Refer to **Appendix E** of this guide for further guidance on projects involving excavations within or adjacent to embankments and cuttings.

The Letter of Instruction issued in response to the Cricklewood accident (NR/BS/LI/045) has been replaced by Network Rail standard NR/L2/CIV/177 ‘Monitoring track over or adjacent to building and civil engineering works’ and now incorporates the recommendations of two subsequent geotechnical incident investigations including Bradwell Abbey embankment on the West Coast Mainline (see plate 30).

Plate 29: Temporary excavation to create works access road and site of derailed freight train at Cricklewood.

Key aspects of this standard include the need to understand the current track geometry and position in relation to allowable tolerance, carry out a risk assessment, and agree a Track Monitoring Plan (including trigger levels and interventions) with Infrastructure Maintenance engineers in advance of the works.

Where the works might affect track support, restraint or geometry and potentially leading to buckling of rail in higher temperatures, the Critical Rail Temperature should be calculated, monitored and managed in accordance with NR/L2/TRK/001/mod14; managing track in hot weather.

Plate 30: Bradwell Abbey toe cut contrary to (emerging) design, affecting track geometry (15 October 2013)

The formal investigation report into the Bradwell Abbey incident identified the underlying causes as:

- Work started on site before the detailed design and track monitoring regime had been submitted for approval, with no AFC design in place..
- Extensive excavation of the embankment was left unsupported for a period of seven days, and which impaired the cohesive strength of the material.
- The Construction Manager and Site Manager did not consider the risk associated with changes made to the planned design during construction work.
- Monitoring arrangements were not in place to check that the construction complied with the design requirements.
- Geotechnical expertise was not employed on site to monitor the embankment during construction works, contrary to the emerging, but uncompleted, design requirements.
- There was a discontinuity of communication between the Contractor and the Designer. This meant that the design conditions for controlling risks were not fully realised and were not incorporated in the Work Package Plan and Task Briefing Sheets.

Section 29 Managing Change

This publication contains a number of learning points where it may be argued that the fullest consideration of constructability, temporary works and temporary conditions hasn't been afforded to the management of changes. This may relate to changes in the assured design triggered by supply chain involvement but is more likely to relate to the management of design change necessitated by discoveries on site.

Change may happen during the delivery of civil engineering works even where designs are based on an appropriate level of survey, investigation with interpretation and assumptions but where absolute certainty of conditions can never exist.

We must be careful that change is identified and managed appropriately with the involvement and endorsement of:

- permanent works and temporary works designers
- key assurance staff, i.e., Contractor's Engineering Manager and Contractor's Responsible Engineers
- Network Rail's engineering representatives

It isn't the aim of this document to describe the process to manage change. This is already baked into key technical and assurance standards and should be recognised within Engineering Management Planning.

The key message is that change must continue to follow the principles within this document and place consideration of constructability and temporary works at its heart regardless of the added time pressures that we may typically expect when dealing with site based discoveries.

Also see sections 13 and 14.

Section 30 Demolition and Dismantling (Deconstruction)

All alteration, demolition and dismantling work, often known as deconstruction activities, should be carefully planned and carried out by competent people to avoid unplanned structural collapse. Demolition and dismantling require a design that incorporates detailed knowledge of the existing structure and how the structure acts.

Further details of the British Standard BS 6187:2011 (Code of practice for full and partial demolition) which gives good practice recommendations for the demolition (both full and partial) of facilities, including buildings and structures is included in **Appendix B**.

In June 1992 during demolition of a three-arch railway overbridge at the west end of St John's Station on the line from London Bridge to Lewisham, there was an unplanned partial collapse of the south arch. See plate 31 below. Two workers beneath the arch at the time of the collapse were killed and four others who were working on top of the arch fell with it sustaining injuries of varying severity.

The HMRI report concluded that the collapse was caused by a faulty system of demolition. Those responsible for developing and approving the method of working failed to recognise that arch bridges carry loads, including their own weight, by transmitting the horizontal and vertical forces to the ends of each arch. In the case of multi-span arch bridges, intermediate arches give support to each other to resist the horizontal thrusts. If any intermediate arch is removed, the neighbouring arches no longer have effective support. This failure to understand structural behaviour was compounded by planning the presence of workers beneath the arches during the demolition works.

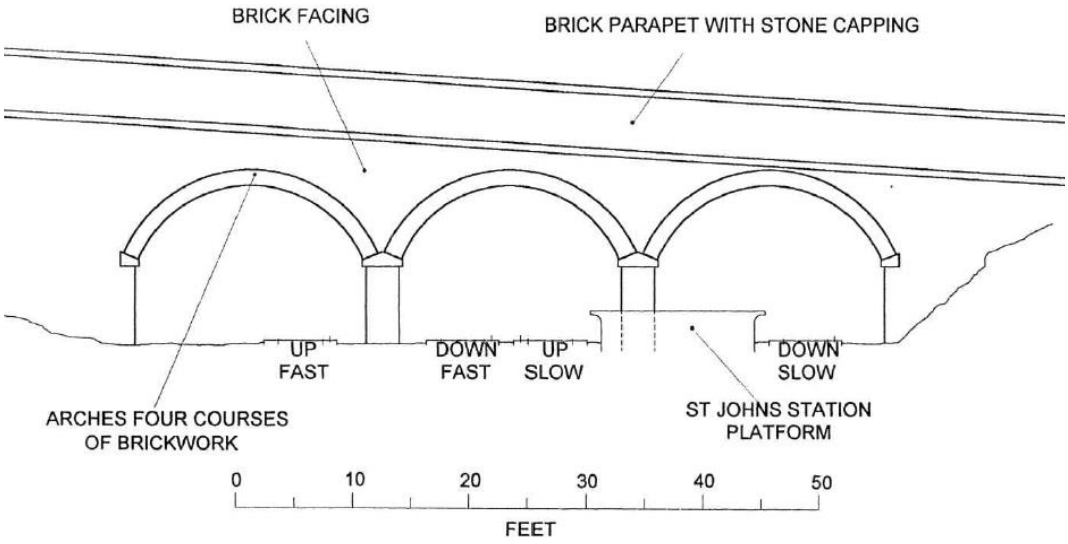


Plate 31: St Johns bridge collapse. (Bridge 106)

The method of working at St John's assumed that the central arch would be demolished first followed by the north and south arches. However, no Temporary Works were put in place to resist the unbalanced forces during the demolition of individual arches.

In April 2012 a similar failure occurred at Lockside Bridge which carries the B1304 over the railway a short distance west of Aldermaston station. The brick substructure of the bridge was believed to have dated back to 1847 and the centre span had been modernised to a steel structure later. The failure occurred during a project planned to replace only the centre span when, during its demolition, the south flanking brick arch collapsed. Refer to plate 32 below.

Lockside Bridge before the incident

Failure of the southern arch during demolition of the centre span

Plate 32: Lockside bridge collapse

In this instance the project team had recognized that the steel span was likely to be resisting horizontal thrusts from the flanking arches and engineered a scheme to try to control the associated risks without provision of additional temporary restraint. Circumstances prevailed that

meant that these risks were not adequately controlled such that the failure occurred. No one was injured.

The St. John's and Lockside accidents demonstrate that, even with the benefit of previous knowledge, great care and engineering attention and close on-site supervision is needed in planning and executing demolition and partial demolition schemes. The guidance in BS 6187 and BS 5975 should always be followed.

An IStructE article on the demolition of arch bridges is listed in **Appendix C.**

Engineering assurance to NR/L2/CIV/003 is required to demonstrate that consideration has been given to calculated stability of assets during various stages of demolition or alteration even where no physical Temporary Works are required.

Also refer to section 9 of NR/GN/CIV/003

It should not be interpreted from this section that only arch structures present risks during demolition, or partial demolition. The maintenance of structural stability during all phases of demolition needs to be studied for all types and assemblies of structure and modes of failure, taking due regard of the condition of that structure and any lack of knowledge of that condition. In all cases, assumptions about condition should be verified so that the actual condition is known.

Appendix A Example of a Constructability Review

Whilst a wide range of projects may have common issues when reviewing Constructability, it is recognised that every project is unique.

Constructability reviews should be tailored to suit a project.

This section includes an example of a Constructability review aimed at Network Rail projects in general. This example is intended to suggest the types of issues that may be relevant to Constructability reviews, however it is ultimately down to those involved in such a review to select an appropriate agenda: -

Constructability Review

Purpose

Constructability and Temporary Works are issues which sometimes do not get enough focus during the design and construction process

Having a clear understanding of these issues, particularly at an early stage of project, is vital to ensuring that there is a robust basis for selecting a single option at PACE Stage 1/2 and that the selected option does not carry undue risk impacting safety, programme, cost, rail network performance or otherwise.

Successful management of risk is achieved by managing several issues including understanding what we don't know, complexity, and the environment in which work is being implemented. Enhanced early knowledge of these issues improves our ability to mitigate risk.

The purpose of this review is to provide a framework, or check list, which enhances focus on Constructability and Temporary works throughout the project life cycle. It is not intended to replace or dilute any associated processes or requirements. It is intended that a review is carried out at various PACE stages.

Whilst some of the questions may appear to not be directly related to Constructability and Temporary Works per se, they are aimed at understanding certainty and the potential for change as change itself introduces risk in many ways such programme/cost pressure.

These reviews should be completed to the best of the team's knowledge. Whilst some questions may "beg" a yes or no answer, a description should be provided where possible. If the answer isn't known, this should be stated openly.

PROJECT: …… PACE STAGE: ……

SUPPLIER: ……

ISSUE	RESPONSE NARRATIVE
Who is responsible for permanent works design?	
Who is the Temporary Works Coordinator?	
Who is the Temporary Works Supervisor?	
Has a construction sequence been defined by the Designer	
Has the construction sequence been agreed with the PC.	
Has Critical Rail Temperature been assessed for hot and cold weather working?	
Have technical stages gates been completed?	
Who is responsible for Temporary Works design?	
Do you believe that the terms of your commission prevent you from adequately discharging your obligations (e.g. financial or time constraints, unknowns, etc.)?	
Do you believe that you have the correct remit?	
Do you consider the works to be simple, complex, or otherwise with respect to Constructability?	
Are the works located on or adjacent to the operational railway or in a high street environment away from the operational railway?	
Does the worksite have OLE/Third Rail?	
Has a Constructability review been undertaken? Provide evidence that it has	
Do you believe that the Constructability review adequately addresses Constructability at this PACE stage? If not, what issues need to be addressed?	

ISSUE	RESPONSE NARRATIVE
What are the key items of plant, for example cranes/piling rigs etc.? Is the required plant readily available or is long lead time ordering required?	
Describe access to the site for people, materials, and plant. Does the access have OLE/Third Rail? Are possessions, isolations, road closures, land purchase, third party land etc. required?	
Does the construction involve the use of novel equipment and/or construction techniques? If so, do you believe that these add significant risk to the works?	
Has the correct DCC been chosen and is the design supported by the correct design deliverables to NR/L2/CIV/003, as the appropriate stage.?	
Is sufficient record data available?	
What level of confidence do you have in the available record data?	
What surveys are required in order to carry out the permanent works designs?	
What surveys are required to carry out the Temporary Works designs?	
Describe how the works interface with the general public/passengers	
Are works to be carried out over the general public and is protection from dropped loads required?	
Are works to be carried out not affecting track or trains.	
Are new or increased permanent and/or temporary utilities required?	
Is staging of works and the need for duplicate temporary facilities understood e.g. temporary ticket office, left luggage, toilets	

ISSUE	RESPONSE NARRATIVE
Are service diversions, temporary duplicate cabling/utility media required?	
Are standard designs being used and if not is there an opportunity to use them?	
Have mock ups, trial erections etc. been considered? Is there a case for them?	
Has the use of modular/prefabricated construction been optimised?	
Is there room to construct the Temporary works without affecting proposed or existing permanent works?	
Are operation and maintenance properly understood, particularly from a safety point of view?	
Do you believe that further investigation into Constructability, records, etc. could lead to significant changes to the permanent works design or to the adoption of a previously discounted option?	
What consultation is likely to be required with neighbours, planning authority, English Heritage, Historic England, equivalent bodies in Wales and Scotland, Canal and Rivers trust, Environment Agency, national Highways and other stakeholders been consulted as appropriate?	
What impact will the works have on surrounding areas? e.g. Noise, dust, light pollution, possible structural movement	
Have all relevant consents been gained.	
Have NR Construction Managers been involved in the design process to make use of local knowledge?	
Will noxious fumes be produced during the works?	
Will monitoring be required e.g. Structural, air quality, track monitoring, noise, etc	

ISSUE	RESPONSE NARRATIVE
Does the work involve confined spaces?	
Does the work involve paint removal and/or painting? Is paint to be removed likely to be lead based?	
What are the main items of temporary work?	
Has working at height been eliminated, minimised or mitigated against during the design process?	
Are all utilities consulted as appropriate and all services have been located?	
Is there an alternative compliant design which may offer a safer solution?	
Are there any sustainability or environmental requirements or constraints which may affect the design?	
Is there a thorough list of Temporary Works and if so how “robust” is the list?	
Are Station entrances visible and sign-posted from all adjacent road and pedestrian routes?	
Are Pedestrian traffic separated as much as possible from other forms of movement within the station?	
Has provision been made for any over-pumping, dewatering, temporary drainage facilities or other temporary means of dealing with water been considered, to enable construction	
Is there a process in place for the Contractor to manage the trigger of fire alarms during construction operations?	
Are the station platforms wide enough to satisfy fire escape strategy with hoardings in place and does the construction sequencing affect the fire strategy/systems?	

ISSUE	RESPONSE NARRATIVE
At AIP stage onwards, is IDC/IDR complete and do these consider both permanent works and temporary works design interfaces with each other and other asset groups?	
Have the Designers Risk assessments eliminated or mitigated risks SFAIRP?	
Have all assumptions been closed out and verified so that there are no imported risks SFAIRP?	
Does the design include for future operations and maintenance requirements, such as provision of safe means of access?	
Is the design constructable?	
Is the design consistent with the construction teams plant, methods and sequences of works and all permanent works requirements	
Have key temporary works requirements been identified and that any likely impact on the permanent works designs have been considered.	

Appendix B Key Statutory Requirements and Guidance

(Current at time of publication and subject to change)

BS5975:2019 - "Code of practice for Temporary Works procedures and the permissible stress design of falsework"

This provides recommendations and guidance on the procedural controls to be applied to all aspects of Temporary Works in the construction industry, as well as specific guidance on the design, specification, construction, use and dismantling of falsework. BS5975 describes procedures as well as technical aspects because the success of falsework and Temporary Works is closely linked to their management. Recommendations are given on the actions that should be taken and the allocation of duties to individuals. It is recommended that the duty of ensuring that all the relevant procedures and checks are carried out be given to one individual known as the "Temporary Works Co-ordinator"

NOTE; *This standard is due for an update to be published in 2023/2024.*

BS EN 12812:2008 Falsework. Performance requirements and general design

This European Standard specifies performance requirements and limit state design methods for two design classes of falsework. It sets out the rules that must be considered to produce a safe falsework structure. It also provides information where falsework is required to support a "permanent structure", or where the design or supply of falsework must be commissioned. This European Standard also gives information on foundations. BS EN 12812:2008 specifies performance requirements for the design of falsework in accordance with one of three classes: A, B1 and B2. Limit state design methods are specified for design Classes B1 and B2. It does not provide guidance for the structural design of Class A. BS 5975, which exists in parallel with this standard and provides recommendations on the design of falsework, without definition of classes or physical parameters and using permissible stress methods, is recommended by Technical Committee B/514 as a suitable method for the structural design of Class A falsework, as defined in BS EN 12812:2008.

"The Construction (Design and Management) Regulations 2015"

CDM Regulations are directly applicable to the design and management of Temporary Works. The definition of a structure in the regulations includes "any formwork, falsework, scaffold or other structure designed or used to provide support or means of access during construction work." Designers include "Temporary Works engineers, including those designing auxiliary structures, such as formwork, falsework, façade retention schemes, scaffolding, and sheet piling." Temporary works Designers have the same Designer duties as Permanent Works Designers on CDM-notifiable projects. Makes several direct or implied references to the design and construction,

inspection and management of Temporary Works and the competence of those involved in their provision.

Also refer to NR/L2/OHS/0047 and associated Forms.

HSE SIM 02/2010/04: - "The management of Temporary Works in the construction industry"

Provides guidance to Inspectors on Temporary Works management in the construction industry and how Inspectors should approach enforcement of the topic. As such it provides a good overview of Temporary Works management.

> *Note; Above SIM remains current in October 2023 but may become superseded when BS5975 is updated.*

Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)

These Regulations (often abbreviated to LOLER) place duties on people and companies who own, operate or have control over lifting equipment. This includes all businesses and organisations whose employees use lifting equipment, whether owned by them or not. In most cases, lifting equipment is also work equipment so the Provision and Use of Work Equipment Regulations (PUWER) will also apply (including ***inspection*** and ***maintenance)***. All lifting operations involving lifting equipment must be properly planned by a competent person, appropriately supervised and carried out in a safe manner.

LOLER also requires that all equipment used for lifting is fit for purpose, appropriate for the task, suitably marked and, in many cases, subject to statutory periodic '***thorough examination***'. Records must be kept of all thorough examinations and any defects found must be reported to both the person responsible for the equipment and the relevant enforcing authority.

BS 6187:2011 Code of practice for full and partial demolition

This British Standard gives good practice recommendations for the demolition (both full and partial) of facilities, including buildings and structures. This standard is therefore applicable to demolition activities undertaken as part of structural refurbishment. It also covers decommissioning. In particular, the standard gives recommendations for:

a) the proper and effective management of demolition processes, including those forming part of structural refurbishment;

b) maintaining structural stability, including through the provision of temporary structural support, where necessary;

c) managing deliberate structural collapse;

d) identifying and establishing responsibilities during all phases of the demolition processes;

e) acquiring a knowledge of the site, including its former uses;

f) managing environmental issues;

g) managing health and safety hazards;

h) carrying out risk assessments and planning the work accordingly;

i) establishing and managing procedures effectively;

j) determining and managing safe exclusion zones.

The standard considers safety, health and issues that affect the protection of the environment.

For the purposes of this standard, demolition activities include, for example, activities that might be known as dismantling, disassembling, demounting, partial demolition, removal, decommissioning, deconstruction and soft stripping, and structural refurbishment, including renovation, rehabilitation, rebuilding, remodelling, reconstruction, redevelopment, restoration, renewal, replanting, development, enlargement, extending, augmenting, conservation, modifications, alterations, structural alterations, upgrading and reroofing.

This standard is not applicable to all structural refurbishment activities; only those involving partial demolition.

It is essential that those carrying out demolition activities possess the necessary levels of competence. Clients or procurers of demolition works need to ensure that all Contractors, Designers and other team members that they propose to engage or appoint are competent to comply with the health and safety requirements necessary to undertake demolition activities. Annex A [of BS 6187] gives guidance on the training and competence required for the activities covered by this standard.

CIRIA C740 Guidance on structural stability during refurbishment; 2017

This guidance provides general guidance for clients, Designers and Contractors and although aimed at smaller projects it is worthwhile reviewing for larger projects and programmes.

PAS 8811;2017 Code of practice for Temporary Works – Client procedures

This PAS gives recommendations on client procedures for Temporary Works. It covers processes, roles, responsibilities and competences, and provides example proforma documentation. The aim of this PAS is to establish a unified approach to client involvement in Temporary Works across all stages (e.g. defining requirements, procurement, installation, use and removal of Temporary Works structures) and eliminate unnecessary procedures and conflicts in order to achieve clarity and minimize delays during compliance and approvals processes and other necessary procedures with respect to Temporary Works.

This PAS is designed to complement BS 5975, Code of practice for Temporary Works and permissible stress design of falsework with the same aim of controlling risk and ensuring adequate procedures. It concentrates on client activities which are not covered by BS 5975.

This PAS does not cover the contractual responsibilities of clients, suppliers or Contractors, and has not been adopted by Network Rail.

Where there are relevant existing standards or industry documents, this PAS refers to these.

It is not the intention of this PAS to replicate existing material.

PAS 8812:2016 Guide to the application of European Standards in Temporary Works design

This PAS gives guidance on the application of European Standards in the design of Temporary Works in the UK. It covers:

a) interpretation of key design approaches applicable to all Temporary Works including:
    1) relationship between Eurocodes and the Temporary Works suite of European Standards;
    2) recommendations on suitable partial factors and combinations of actions;
    3) recommendations on appropriate analysis approach;
    4) stability considerations;
    5) considerations on reuse of equipment;
b) clarification of design requirements for identified groups of Temporary Works.

This PAS has been designed to facilitate consistency in the design approach to Temporary Works and remove the uncertainties for Temporary Works Designers.

Appendix C Useful References / Resources

- NR Health & Safety by Design; Building and Civils Working Group (H&SbD B&C WG)

  https://safety.networkrail.co.uk/safety/prevention-through-engineering-and-design/safe-by-design-groups/building-and-civils/

  H&SbD B&C WG Lifesaving Rules Aide-Memoir
  H&SbD B&C WG – Guidance on use of Warning Triangles on Engineering Drawings
  H&SbD B&C WG Principles
  This document.

- **Early Contractor Involvement in Building Procurement**: Contracts, Partnering, and Project Management by David Mosey. Publisher: John Wiley and Sons Ltd. ISBN: 9781405196451
- **SCI Publication 178**: Design for Construction
- Temporary Works: Principles of Design and Construction

https://www.icevirtuallibrary.com/doi/book/10.1680/twse.63389

- **Management of the Design and Procurement of Temporary Works**. July 2012. TW/12/006. Published by Temporary Works Forum https://twforum.connectedcommunity.org/viewdocument/management-of-the-design-and-procur
- **Stockpiles** - https://www.twforum.org.uk/viewdocument/twf-information-sheet-no-5-stockp
- **Temporary Works Forum guidance** There is a wealth of useful guidance published on the TWf website and available to registered users. Some of this guidance has been developed in conjunction with Network Rail, who are members. Up to date documents can be found at: https://www.twforum.org.uk/home.
- BS 6187:2011 Code of practice for full and partial demolition. British Standards Online (BSOL).

https://bsol.bsigroup.com

- PAS 8811: 2017 Code of practice for Temporary Works – Client procedures
- PAS 8812: 2016 Guide to the application of European Standards in Temporary Works design
- Institution of Structural Engineers

Temporary Works Toolkit - a series of articles aimed primarily at assisting the Permanent Works Designer with Temporary Works issues

- National Access and Scaffolding Confederation publications

NASC - National Access & Scaffolding Confederation

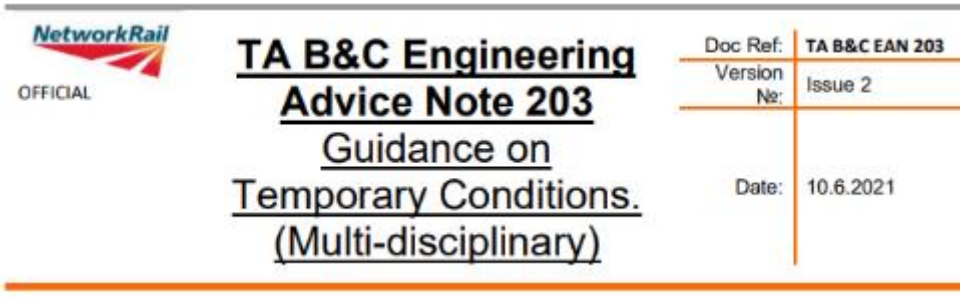
- BS5975: - “Code of practice for Temporary Works procedures and the permissible stress design of falsework”

BS 5975 - Temporary Works Procedures | BSI (bsigroup.com)

- Network Rail Engineering Advise Note EAN203 guidance on temporary Conditions.

This is available to all with NR systems access.

Engineering-Advice-Note-EAN-203.-Temporary-Conditions-Guidance



- Soft Hazards guidance. See NR/GN/CIV/003 section 4 and below information.

The ICE publication “Designing a Safer Built Environment”, by J Carpenter, ISBN 978-0-7277-6582-6, expands on the concept of soft hazards.

CROSS UK has provided further guidance on the concept of Soft Hazards which refers to the above publication. See below link to the CROSS UK Safety Alert on the management of design related risks: -

https://www.cross-safety.org/sites/default/files/2021-12/cross_safety_alert_the_management_of_design_related_risks.pdf

- CIRIA guidance

Store Home (ciria.org)

- Network rail “Our Principles of Good Design” and associated buildings and architecture design guidance.

Buildings and architecture design guidance - Network Rail

- Concrete Bridge Development Group Technical Guide 16 -Temporary works for concrete bridges

TG16 Temporary Works for Concrete bridges (concretebookshop.com)

- An article from the IStructE on the demolition of arch bridges, from 1994, can be found in below link; available to members.

Demolition of Arch Bridges – The Institution of Structural Engineers (istructe.org)

Appendix D Key Points

MAKING A START.	
Collaboration, teamwork, communication.	Let's work together.
Pre Construction Information	Is it adequate. What is missing. What do we need which we have not got.
Focus and planning.	Thinking ahead. Temporary Works Schedule (PCI) Temporary Works Register. (Design & construction development)
Competence and expertise.	Right people for the job.
Constructability reviews.	Can we do it better / safer? Better integrate Permanent works and temporary works designs.
Validation of design assumptions.	Share assumptions with all parties. Validate all assumptions early.
Early Contractor Involvement (ECI)	Benefit from practical experience.
Construction sequence.	Critical for safe construction, agreed by all parties and not varied without agreement.
Communication of design brief.	Design brief to be issued to Temporary Works Designer
Communication of Temporary Works philosophy.	Temporary and permanent works affect each other.

DESIGN INTERACTION.	
Lessons learnt.	Consult NR and supply chain databases of lessons learnt and good practice.

Understand the site.	Topology, hydrology, ground conditions, services, condition surveys, constraints etc.
Engineering assurance.	Compliance ensures safe design and checking.
Gauging and clearances.	IDC checks vital, as is site monitoring.
Changes to Temporary Works.	Should be communicated to all parties. Do not make ad-hoc changes on site. Change control process to include referring back to Designer for agreement to changes.

THE DETAILS.	
Piling / crane platforms.	Use approved design methods / guides. NR/L3/CIV/0063
Hoardings.	Stability vital, track proximity, pedestrian flow.
Demolition / dismantling.	Crucial to understand structural stability at all stages of demolition.
Earthing and bonding.	IDC - essential.
Protection decks.	Public safety. Concourse, platforms, tracks.
Earthworks instability / trenches.	Known risks of excavation near tracks.
Track geometry.	IDC - possible influence of Temporary Works on alignment.
Loading / lifting / transportation.	Load and crane stability. LOLER.
Scaffolding.	Qualified and competent Designer, checker & installer.

Taking into use & Handback.	
NR/L2/CIV/003/FormE Certificate of fitness to be taken into use	FormE Certificate to be completed in accordance with NR/L2/CIV/003

As-constructed records	As-Constructed records to be complete and accurate including provision of details of temporary works required to build, operate and maintain, including capture of retained items such as foundations in the CDM H&S File to help with future alteration and eventual demolition. Refer to requirements in NR/L2/CIV/003 and NR/L2/OHS/0047
Arrangements for the exchange of asset data and the continuing maintenance of assets undergoing change,	Comply with requirements of the Asset Management Plan (AMP) standard NR/L2/MTC/089.

Appendix E Guidance on the criteria for determining when a Temporary Works Design may be required for excavation near to the track

All excavations have the potential to generate instability and therefore require Temporary Works design. In simple cases this may only be the specification of normal good practice.

However, where there is a potential for affecting the safety of the railway, or affecting the safety of any persons other than those under the control of the construction organisation (Contractor / Principal Contractor), a more detailed design and Form C or Form H approval is required, depending on DCC. See NR/L2/CIV/003 clauses 13 and 14.

The Track Support Zone (TSZ) has little to do with the stability of the earthwork. As the name suggests, the TSZ is about performance of the track bed. Embankments can still be destabilised by excavations which are not in the TSZ, hence the effect on the TSZ alone is not a good guide to the need for temporary works for earthworks.

In assessing the potential for instability of excavations affecting railway infrastructure consideration of three criteria is required:

1. Impact of the excavation on the Track Support Zone – i.e. the potential for the excavation to directly undermine the formation supporting the track bed with impacts on Track Handback and Critical Rail Temperature
2. Impact of the excavation on the Track Support Zone – i.e. the potential for the excavation to remove support to the zone of ground deemed to be bearing load from the infrastructure, affecting its stability
3. Impact of the excavation on slope stability – i.e. the potential for the excavation to affects the balance of slope forces

The Track Support Zone and zone of influence in Figure E1 is taken from table 2 of NR/L2/CIV/177; Monitoring track over or adjacent to Construction Works.

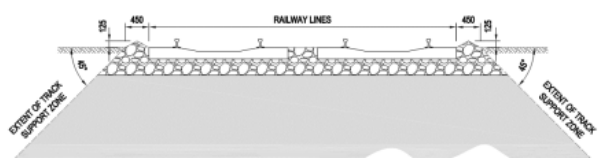
Track Support Zone (TSZ)	Any area beneath the track that supports the position of the track. This can generally be assumed to be an area bounded within a 45 degree plane extending below and beyond the top of the ballast shoulder however it can vary depending on ground conditions. The diagram below shows the track support zone as a shaded area, where the ballast shoulder is assumed to have a width of 450 mm and a depth of 125 mm from the top of the sleeper. The track support zone extends indefinitely unless otherwise demonstrated through analysis of ground conditions and justified with engineering judgement. 

Figure E1 – Track Support Zone, taken from NR/L2/CIV/177 Table 2.

NR/L2/CIV/177 states that the zone of influence will need to be determined for each project as it will vary depending upon factors such as ground conditions, type of infrastructure and works planned**.** Guidance below should therefore be read in that context by a suitably qualified geotechnical engineer.

Geotechnical advice will be required to determine the stability of the embankments and cuttings and thereby the likely impact of any excavations. For example, stability issues for natural rock formed slopes are very different to those formed in soils. Historic slopes with existing instability should also be considered differently to recently constructed stable earthworks. In this context it should be remembered that the Track Support Zone has little to do with the stability of slopes but will always require consideration whilst planning interventions, and for Critical Rail Temperature (CRT) planning.

Key points to be considered in planning temporary excavations for soil formed earthworks:

- Even small excavations into, or at the toe of, unstable embankments have the potential to cause significant slope instability, even where there is no impact on the Track Support Zone
- Good designs should minimise the amount of excavation into embankments and wherever possible seek to progressively stabilise slopes.
- Removing or altering existing stabilisation measures (such as toe berms) is an additional risk and needs to be very carefully considered
- Stand-up times for clays should not be relied upon as the sole element of temporary excavation design where failure could affect an open line.
- Careful control measures to limit bench heights as per Network Rail Standard Details, restrict bay lengths and to restore slope profiles at the end of each shift are always required – monitoring and inspection alone are not sufficient since movement can occur very rapidly. To benefit from the effects of soil arching, normally a maximum bay width of about 6m should be adopted, but this may reduce in poorer ground or where there are particular concerns over stability.
- Effects of water & drainage on stability should always be considered for temporary excavations.
- Where there is any significant potential for slope movements which could affect the safety of the line then temporary support or stabilisation measures will be required (i.e. a Form C will be required).
- During the works seek early specialist geotechnical advice where there are concerns over temporary excavation stability.

The following Figure E2 is proposed as a general guide to risk levels for temporary works to soil-formed slopes where lines remain open during works. Risks may be further mitigated where possession working is proposed:

Risk Level *prior to mitigation*	Excavation details	Temporary works design
LOW to MODERATE	• No excavation into slope more than nominal benching into slope, **and** • No removal of existing stabilisation measures**, and** • No excavation at toe greater than 500mm, **and** • Bay widths are no more than ~6m, **and** • *No excavation within track support zone*	• ***Confirm with DPE/PE(B&C) whether Form C or H is or is not required to NR/L2/CIV/003*** • Temporary works issues may be addressed by observing good excavation practice including controls on bay widths, • Temporary excavation profiles, method of working and routine controls to be set out clearly on construction drawings. *Where no Form C or H is proposed designer to confirm no unusual stability issues associated with the earthwork.*
MODERATE to HIGH	• Any slope where more than nominal benching, **and/or** • There is removal of existing stabilisation, **and/or** • Bay widths of more than ~6m are proposed, **and/or** • There is excavation at toe greater than 500mmm • **BUT** *there is no excavation within track support zone*	• ***Confirm with DPE/PE(B&C) whether Form C or H is or is not required to NR/L2/CIV/003*** • Review design requirement for excavations and potential for temporary support e.g. soil nailing, sheet piling, trench boxes. • Temporary excavation profiles, detailed method of working and specific controls to be set out clearly on construction drawings. • *Where no Form C or H is proposed designer to confirm no unusual stability issues associated with the earthwork.*
HIGH to VERY HIGH	• **Any** slope where track support zone is affected by excavations • Any excavation falling outside the conditions for the 2 categories set out above or where slope profiles cannot be restored at the end of each shift.	• **Form C design required to NR/L2/CIV/003** • Temporary stabilisation normally required (e.g. soil nailing, sheet piling) • Consider alternative design solutions • Temporary excavation profiles, detailed method of working and extensive controls to be fully documented

Figure E2. Guidance on the criteria for determining when a Temporary Works Design may be required for excavation near to the track where lines remain open during works.

***NOTE 1**; Earthworks which may exists outside the TSZ defined boundary line may nevertheless influence the stability of the earthworks inside the TSZ.*

***NOTE 2**; Requirements of NR/L2/CIV/003, E.G. Clauses 13 and 14 for Temporary works, to be adhered to in all cases.*

***NOTE 3**; A FormC or FormH is to be submitted for acceptance by Network Rail, to NR/L2/CIV/003, except that a NR/L2/CIV/003/FormC or FormH is not required under the following circumstances:*

a) Where the presence or failure of the temporary works would not affect the safety of the railway; or

b) Where the presence or failure of the temporary works would not affect the safety of any persons other than those under the control of the construction organisation (Contractor/Principal Contractor).

Permanent and temporary drainage design around earthworks should consider the potential for extreme events exceeding design capacity leading to slope failures or washout events affecting track. Where such impacts on track could occur and the potential for works to concentrate or

redirect otherwise more diffuse flows in the temporary and permanent states should be addressed and as required suitable safe overflow mechanisms should be incorporated.

Appendix F Warning to clients, and other members of project teams, on capacity of existing assets to support temporary works.

Clients, and other members of project teams, need to risk review as part of pre-construction phases, if any required temporary Works are to be supported from existing assets, whose loadbearing capacity may or may not be known.

Clients, and other members of project teams, sometimes fail to assess the impact to the project, in terms of safety, program & cost, of how temporary works may reasonably be installed and supported, at early stages.

Sometimes, some would say too often, temporary works installations are assumed to be solely the responsibility of the contractor and to be determined during the post-contract award phase.

The Principal Designer often fails to advise the client adequately as to the very significant risk if the pre-construction considerations do not investigate, or interrogate, the viability of expected temporary works arrangements. When the PD does offer such advice, budget constraints or procurement become obstacles to determination of viability at early stages.

Clients sometimes execute contracts in the belief that temporary works arrangements may be simple and straightforward to execute when they are not.

An example of a client failing to properly interrogate the viability of anticipated temporary works revolves around the placement or suspending of access works scaffolds from existing structures, as illustrated in the below example.

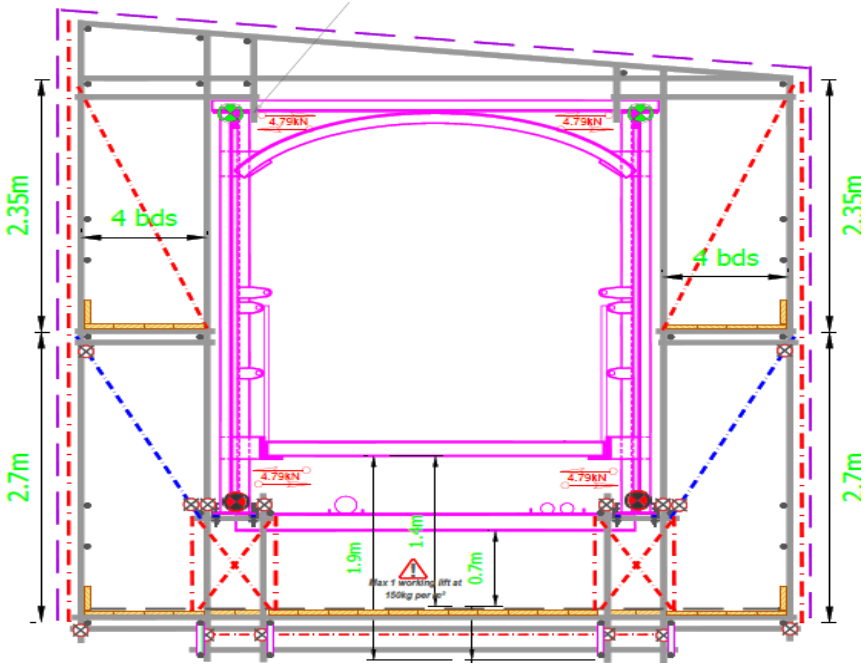


Figure E3: Typical Encapsulated Suspended Scaffold Hung from Existing Weak Bridge.

The above is an example of an existing footbridge over a river with proposed hung scaffold and encapsulation. The Client in this case did little pre-construction assessment and assumed

that the access and works scaffold could most likely be readily supported from the existing lightweight bridge structure.

In the event the bridge was structurally assessed by the Principal Contractor post-contract and discovered to fail assessment, both for carrying the temporary works access & scaffolds, and also in the future permanent works state.

Design, negotiation of cost and implementation of strengthening to the bridge, which needed be carried out in advance to facilitate the future refurbishment works scaffolding, delayed project program by several months, inflated costs, increased safety risks and failed public expectations.

This also led to a significant contractual dispute over what were considered reasonable Client and Principal Contractor expectations ahead of works, even though the Contractor specifically excluded the impact of any possible strengthening in their tender offer, due to the unknown need, nature and extent of any such works at tender stage.

Those supporting clients in the pre-construction phase (this might be the Principal Designer, designers and contractors involved in ECI) should raise deficiencies in technical understanding of the assets at an early stage such that the client can undertake the necessary steps to locate or procure the missing information. This might be assessment reports, record information, surveys, ground investigation, etc

It is recommended that clients (supported by others) as part of the pre-construction phases, undertake the following; -

A. Undertake an outline assessment of a structure to support notional temporary works,
B. Undertake appropriate preliminary design of the temporary works to ensure existing structures have capacity,
C. Provide A & B above to tenderers, to demonstrate the viability of the project design.

Without the above additional pre-construction effort the client will be at risk of contract dispute, extended programme, missed milestones, cost over-runs & very disappointed stakeholders.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