

*Infrastructure Projects*

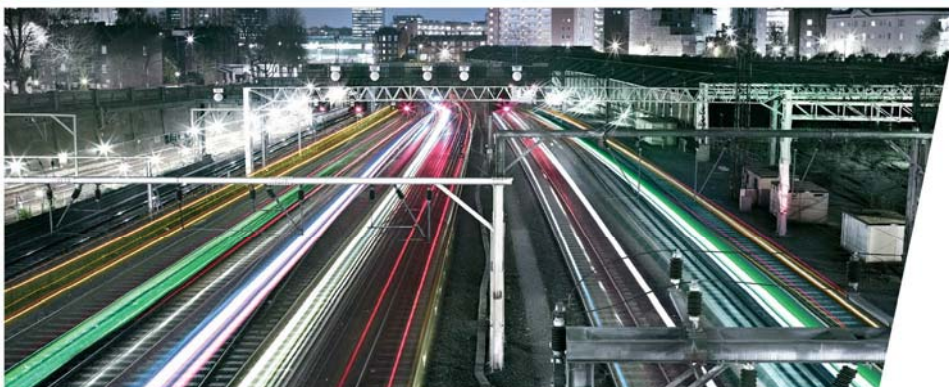


# Safe by Design.

**Buildings & Civils Working Group.**

**Guidance Note:**

**Early Focus on Constructability and Temporary Works**



<b>Network Rail Safe by Design</b>	<b>Date:</b>	<b>15 May 2019</b>
<b>Guidance Note – Early Focus on Constructability and Temporary Works</b>	<b>Issue:</b>	<b>3</b>

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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.

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## 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.

**Constructability** can be defined as:

*“the extent to which the design of a building or construction project and its environment facilitates ease of construction, subject to the overall requirements of the building 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 “end game” 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.

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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, but should not be limited to these points only.



**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 needs to be detailed to ensure stability at all times, and the sequence communicated to the workforce.*

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## Section 2 Scope

The scope of this document includes Constructability and Temporary Works associated with buildings, building services and civil engineering projects on Network Rail controlled infrastructure. Although written by the Safe 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 Governance for Railway Investment Projects (GRIP) stages. Allowing Constructability and Temporary Works issues to inform the Option Selection (GRIP 3) process will enable activities past Option Selection to be developed which are aligned to good practice from the start.

This Safe 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, although 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. Examples of alternative facilities include, new access points and access roads, duplicate services such as power and lighting, and temporary station facilities such as waiting rooms, footbridges, 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 ‘Safe by Design’ principles when assessing optimised solutions for all aspects of the work to be undertaken. Safety systems for personnel and

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materials handling must 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.

Those planning the works must 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/INI/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.

This applies to all projects and the organisations working on projects that change, renew, enhance or remove Network Rail infrastructure assets. It applies to all phases of a project as applicable under GRIP and the Integrated Engineering Life Cycle for Projects (iELCP). All types of project are applicable including, but not limited to:

- a) feasibility studies;
- b) option selection
- c) design stages
- d) construction stages;
- e) testing and commissioning;
- f) handover/handback
- g) maintenance;
- h) asset protection;
- i) asset recovery;
- j) de-commissioning and demolition;
- k) projects which protect Network Rail's asset when a party other than Network Rail carries out work on, over or under Network Rail property;
- l) projects carried out by an Alliance between Network Rail and another party /other parties;
- m) all necessary Temporary Works;
- n) emergency works (once the immediate requirements to make the railway safe have been met.)

There are several exceptions, as listed in the standard.

Standard NR/L2/INI/02009 also applies to projects which protect Network Rail's asset when a party other than Network Rail carries out work on, over or under Network Rail property, with outside party and third party works defined in Network Rail standard NR/L1/CIV/094 (National Asset Protection and Optimisation Delivery Framework.)

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The requirements defined within NR/L2/INI/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 shall be conducted in accordance with guidance provided within standard NR/L2/INI/02009. The processes used for this shall 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.

This section should be read in conjunction with Section 10.

Network Rail is a railway duty holder and is required to use the CSM-REA method 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 shall be produced. Network Rail has specified the process for application of CSM-REA in standard NR/L2/RSE/100/02.

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

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

Designing a scheme without an appropriate understanding of the site is fundamentally flawed.

Construction sites in a railway environment often bring a unique set of challenges.

Key record information held by the Client must be provided at an early stage to the other CDM duty holders to help assist them with the safe planning and development of construction works.

If there is insufficient record information available a prioritised schedule of survey requirements should be formulated by the Designer.

Surveys, particularly when intrusive, can be disproportionately expensive and in some circumstances can add little value. Appropriate investigation needs to be undertaken proportionate to the risks involved. Use of conservative assumptions may be more cost effective. There is a requirement to use informed engineering judgement to achieve this.

The Designer shall also consider requirements for survey and investigation to inform likely Temporary Works designs and the CEM should be looking to integrate the needs of all phases of the project. For example, an additional window sample for a crane pad represents a modest additional cost when carried out within wider scope of works. This is easy to coordinate within a Design and Build arrangement.



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This early survey work will both inform the design and highlight areas of risk such as poorly consolidated earthworks beneath the track, mine workings and existing structures assets that may be in poor condition

Reference should be made to NR standard NR/GN/CIV/208 Ground Investigation. This document provides guidance to Network Rail and its Contractors who have responsibilities for complying with the reporting requirements from ground investigations in NR/L2/CIV/086/Mod02 and NR/L3/CIV/071

Validation of records drawings may be necessary and should be accommodated within the survey scope if possible.

On projects where speed of construction is paramount, for example a Railway Electrification Project, Piezocone Penetration Test (CPTu) could be useful to check overhead line foundation allocations based on standard foundation designs (see NR/L2/CIV/074) on balance of quality of information, cost, and construction time. CPTu is a in situ testing method used to determine the geotechnical engineering properties of soils and assessing subsurface stratigraphy, relative density, strength and equilibrium groundwater pressures. The test is a special type of Cone Penetration Test (CPT) which allows additional measurement of excess pore pressure generated during the penetration. Indeed, "u" in CPTu represents the porewater pressure. Due to its efficiency and precision, the CPTu is becoming one of the commonly used in-situ testing methods in geotechnical investigation, but in all cases expert advice should be sought.

Designers should familiarise themselves with the site and the available access and transportation logistics, both in terms of time and location, for these issues to inform their design. Whilst site visits are often helpful, Designers should also utilise desk-based resources including new technologies to gain the fullest appreciation of the site constraints.

Resources such as Geo-RINM, Aerial Photography, Drones, and British Geological Survey etc. can be extremely useful

Speaking to Asset Managers and Maintainers, who often have detailed records and knowledge of the infrastructure, should be considered at an early stage.

CDM Pre-Construction Information needs to be robust, including all the aforementioned. Refer to HSE L153 guidance on the CDM regulations and NR standard NR/L2/OHS/0047.

## **Section 6 Focus and Planning**

Many of the problems caused by Constructability and/or 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 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 of a project, particularly at feasibility, option selection, approval in principle and detailed design. It

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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.

On occasions project teams do not recognise a situation as being 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 out-sourced. 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**

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

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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

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.

## **Section 7 Capturing and Cascading Lessons Learnt (and Good Practice)**

For engineers, 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.

At the time of publication Network Rail have plans to make Lessons Learnt and Good Practice examples available to all in the industry through a single platform, to compliment information already available on Safety Central. At time of publication the following links are available: -

Safety Central: -

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

Lessons Learnt: -

<https://www.safety.networkrail.co.uk/Alerts-and-Campaign/Lessons-Learnt>

*Note. Network Rail intends to develop a centrally based, accessible & searchable depository for lessons learnt and good practice during CP6.*

## **Section 8 Building Information Modelling (BIM)**

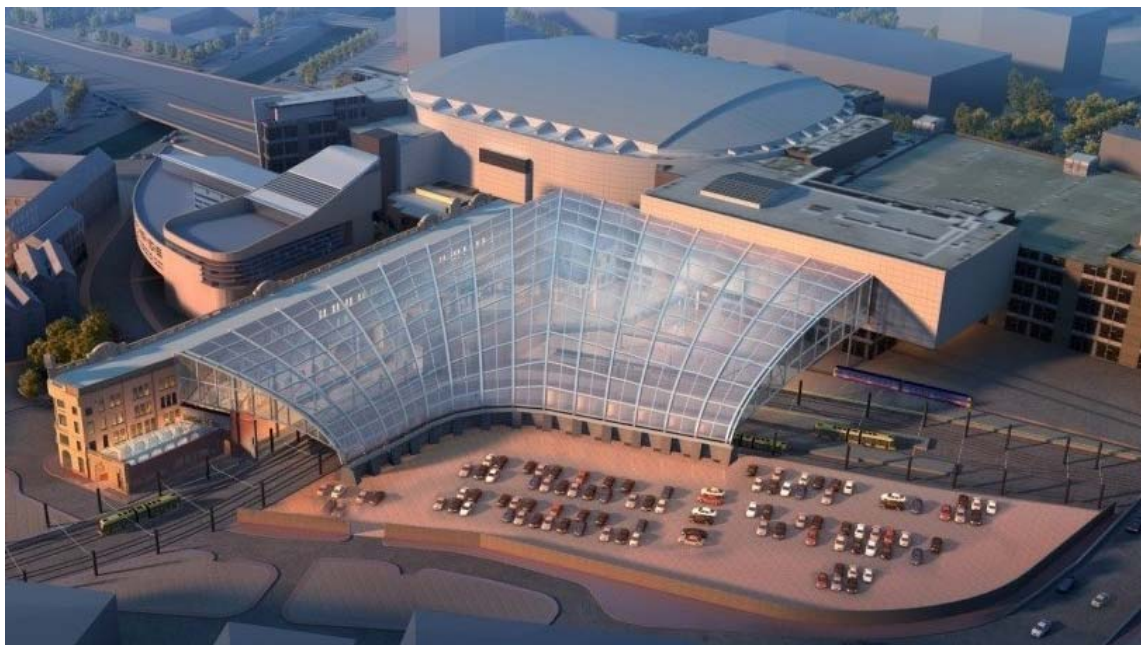
More projects are designed using the many advantages of building information modelling and Network Rail has embarked on a programme of ensuring future programmes make best use of BIM. In the context of this guidance BIM enabled projects can be especially useful for the following:

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- a) Capture reality i.e. ensure that surveys reflect existing infrastructure hence new permanent and Temporary Works designs fit.
- b) Cut down rework by ensuring that clashes are detected, 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 resequencing 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.

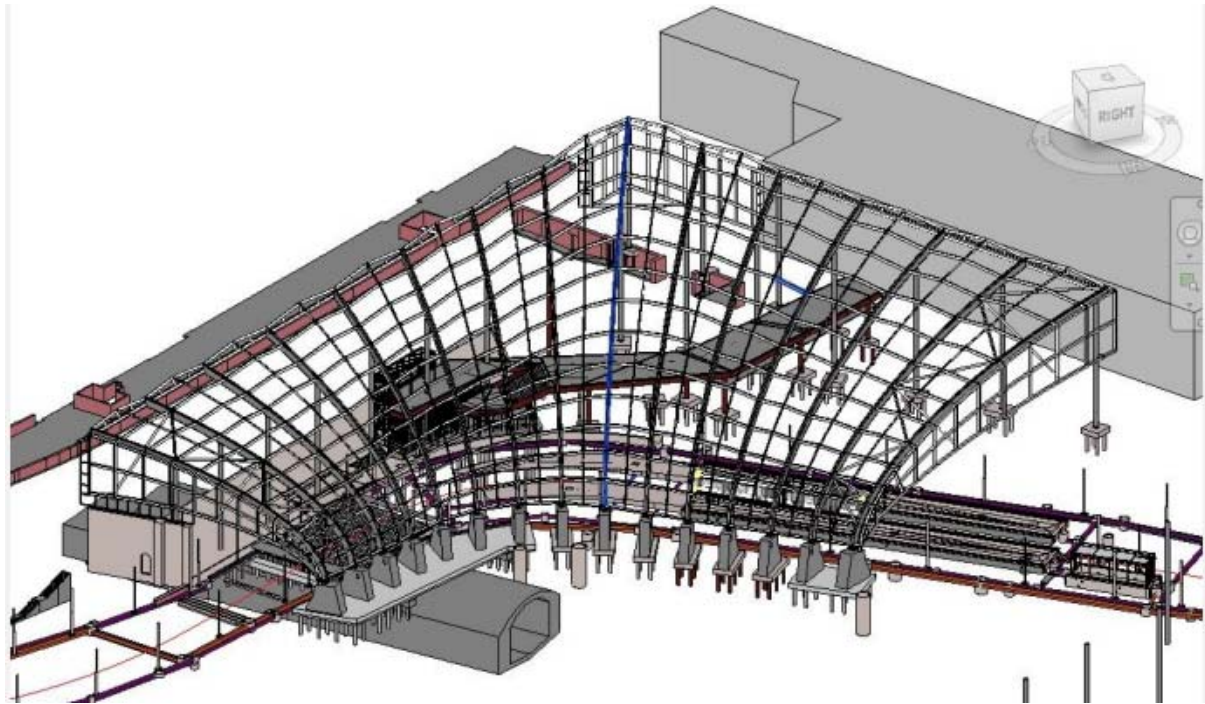
Projects should consider the advantages of BIM at early GRIP stage to maximise the benefits throughout the project lifecycle.

The Manchester Victoria Station Redevelopment project was an early example of the development of a complex multi discipline railway project in a Level 2 BIM environment.

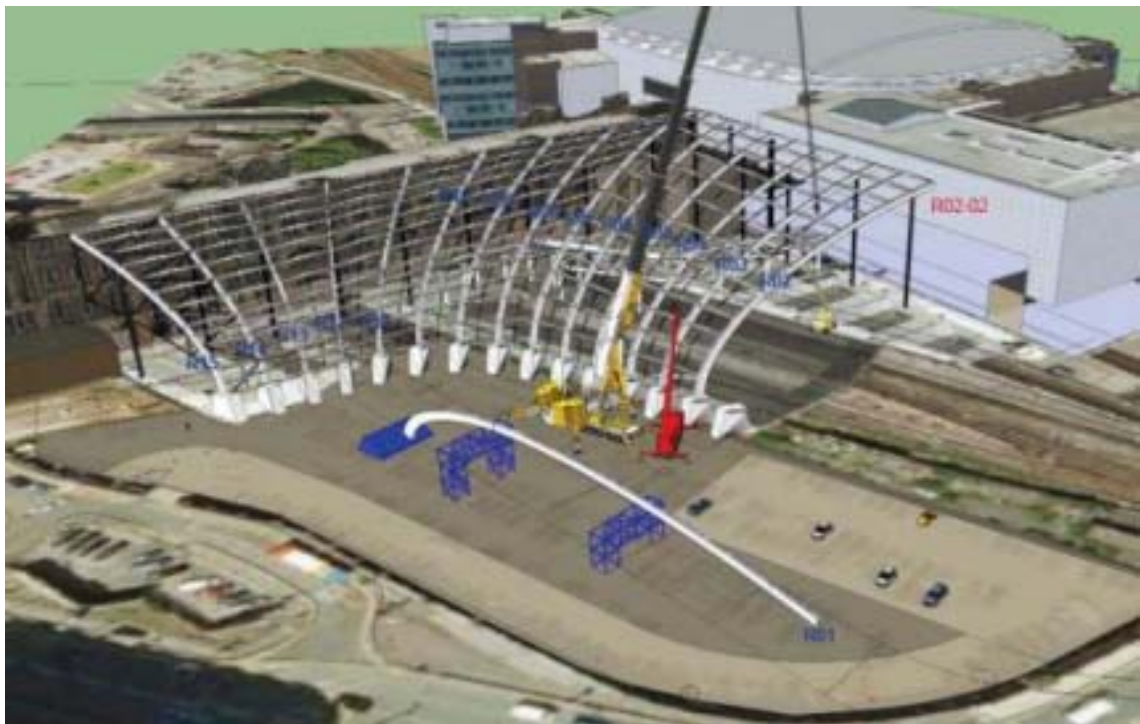


**Plate 2: Manchester Victoria Station Visualisation from complete BIM model**

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**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.*

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**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 that the permanent works in terms of approvals from third party bodies. For instance, it may not be possible to erect a

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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 assurance process for Buildings, Civils and Architecture is contained in NR/L2/CIV/003. (Other disciplines have other assurance standards, as listed in NT/L2/INI/02009.) Particular attention should be given to CIV/003 Section 12.2 which mandates the elevation of check categories dependent upon the relationship between the design and construction organisations. Notwithstanding previous comments about the range of organisations preparing designs, it is not un-common for Temporary Works to be designed by a Contractor’s “in-house” team” and this will influence the check category.

Temporary works designs are subject to engineering review by a Network Rail Project Engineer using the DRN process. 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. 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. 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 to also check that there are suitable electrical clearances.

### **Conclusion**

- The Temporary Works installation has three different Designers, a scaffolding Designer, a structural engineer to check the existing building, and an electrical engineer to design the bonding and check electrical clearances.

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- Electrical clearances must always be checked.
- Three separate design submissions are required which need to be integrated.
- The CEM shall carry out an inter-disciplinary check (in accordance with NR/L2/INI/02009) and submit this with the designs

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 Register will usually need to be updated as project progresses.

(Also refer to Section 6.2 of BS5975:2019)

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 minimum should include;

- Location/description of Temporary Works
- Design check category.
- High or low risk check category for Work Package Planning, determined as defined in NR/L3/INICP/0044 and agreed with CEM and DPE/PE
- Confirmation of coordination between all permanent and Temporary works has been considered
- 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.
- Permit to Load/Permit to Dismantle

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

*Note. Clause 5.6 of NR/L2/CIV/003 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 Form F002/3 assurance regime but should nevertheless be on the Register.*



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## 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 GRIP 3 option selection design is taken forward by a different Designer at GRIP 4 AIP stage
- Permanent Works Designer and Temporary Works Designer
- Temporary Works Designer and Contractor

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 (GRIP 3) 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.

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- Temporary Works Design Philosophy and relevant codes (e.g. limit state vs permissible stress) should be checked against permanent work philosophy 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.

<https://cdn.networkrail.co.uk/wp-content/uploads/2019/03/Our-Principles-of-Good-Design.pdf>

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 the passenger experience.

## **Section 12 Validation of Design Assumptions / Exclusions**

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.

More importantly 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 can lead to adoption of non-optimal and/or unsafe design solutions. All design assumptions must be validated. Design exclusions must 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.

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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 must be clearly communicated to construction workers and in a way that they can easily understand. This could to be achieved by:

- Coordination between Designer and Contractor.
- Using ERIC principles: eliminate, reduce, inform, control.
- 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 must 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. 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

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- 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 must 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.

In all instances, it is essential that clear and concise information is provided to enable the Contractor to understand the design requirements so that he 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
- Stability provisions for structural frames for buildings and roofs/canopies
- Temporary support during demolition – refer to Section 29

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**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.*

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## 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 must be effectively communicated to the Designer for validation prior to execution of the works.

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.

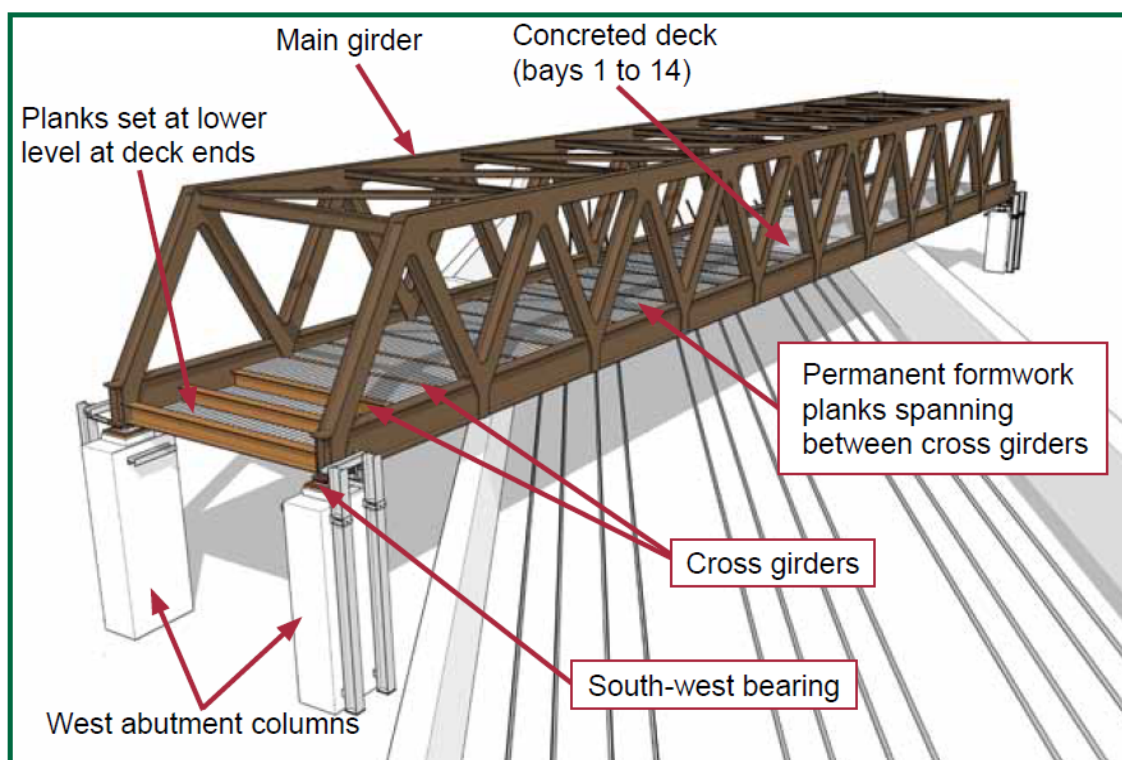


Plate 7 : GE 19 schematic showing main deck components.

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**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 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;

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## 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 must be overcome to safely and successfully deliver a project. 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.

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 must be in turn assessed by a competent person using a suitable competence framework.

Further guidance on collaboration can be found in BS11000, now replaced by ISO44001 (Collaborative business relationships).

## 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.

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 Authority to Work process outlined in NR/L2/INI/02009 Module 2



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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 Forms 001 (where applicable) , 002 & 003 (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 supervision where necessary, by SQEP. Supervisors must be experienced in working in the particular confines of the Railway, or in turn supervised by those who are.

## 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:

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- Early creation of delivery team with partnership approach and team ethos based on long-term relationships
- More scope for innovation to offer better value
- Improved risk management
- Selection of suppliers based on best value
- 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 (GRIP 3) 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,

## 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:

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- 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 shall 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 are a useful tool to ensure that designs are inclusive.

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

An example of 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
- 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 TG20:13 Technical Guidance on the use of BS EN 12811-1

For the erection and construction of scaffolding guidance is taken from NASC SG4:15 The use of Fall Arrest Equipment Whilst Erecting, Altering & Dismantling Scaffolding.

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

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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 must 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.

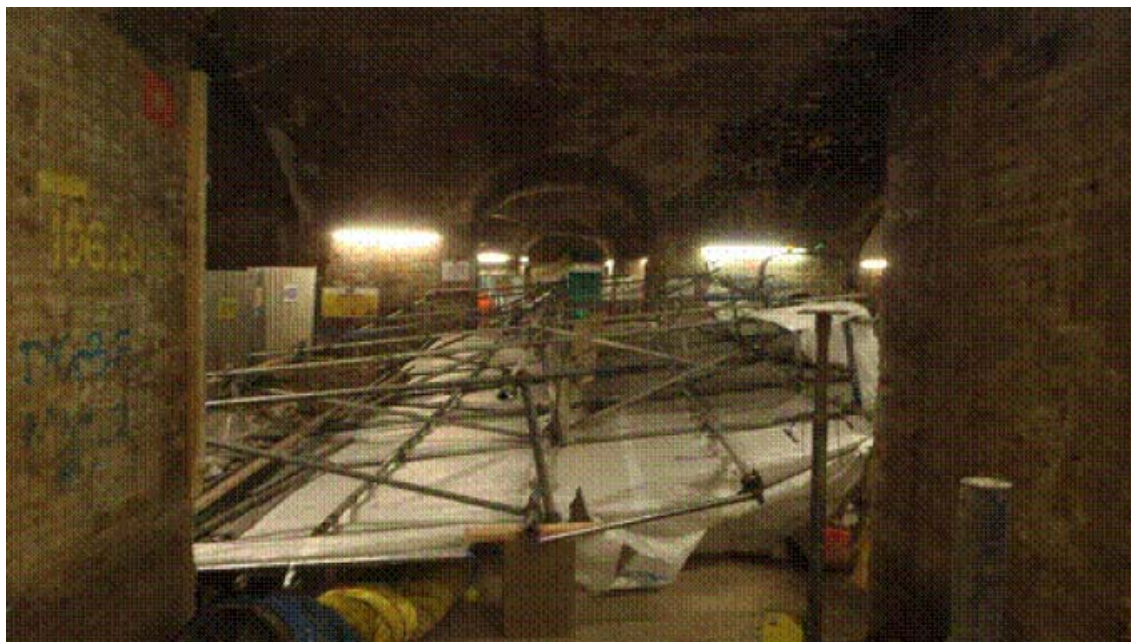
When working close to OLE and other exposed live electrical equipment the use of GRP or other non-conducting materials are necessary. Design of bonding will be required for metallic items in some situations adjacent to OLE areas. Advice of the E&P Project Engineer should always be sought.

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 important elements to ensure designed and installed correctly. In Plate 9, 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 must be given to the design of bespoke scaffolds particularly with respect to connections and overall stability.

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**Plate 9: 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.*

## **Section 20 Piling Rig / Crane Working Platforms**

The requirements for piling adjacent to the railway are set out in NR/L3/INI/CP0063. The principles of this standard also apply to the use of cranes. Particular attention is drawn to Section 8 which sets out the requirements for design and use of working platforms for piling rigs and cranes. 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 must be assured in accordance with NR/L2/CIV/003. Section 10 applies.

*Note at the time of writing (May 2019) CP0063 is undergoing updates to align with CIV/003 and other standards.*

In 2003 a piling rig collapsed onto the London Tilbury Southend lines. See Plate 10. 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

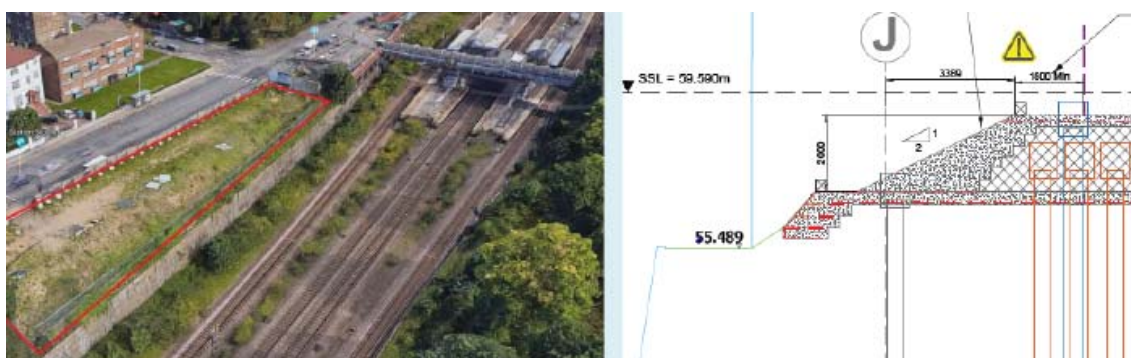
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days. The subsequent investigation found that a significant contributing factor was the breakdown of communication between senior and junior site managers, who were not aware how critical the piling platform and design was, or the need to involve the platform Designer in any repairs.



**Plate 10: 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 11: 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.*

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Further guidance on working platform design is given in Appendix 3 from TWf. “Working Platforms: Design of granular working platforms for construction plant - A guide to good practice”

## 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 Form (TWf) ref: Hoardings a Guide to Good Practice TWf2012: 01(revised April 2014), though this does not include railway specific loading requirements covered by NR and RSSB standards such as for min platform widths and from loads from the aerodynamic effects of passing trains.

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 PEDFLOW predictions \*
- Checking that any equipment to be fixed to hoardings post erection does not affect clearances and/or pedflow

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- 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.*

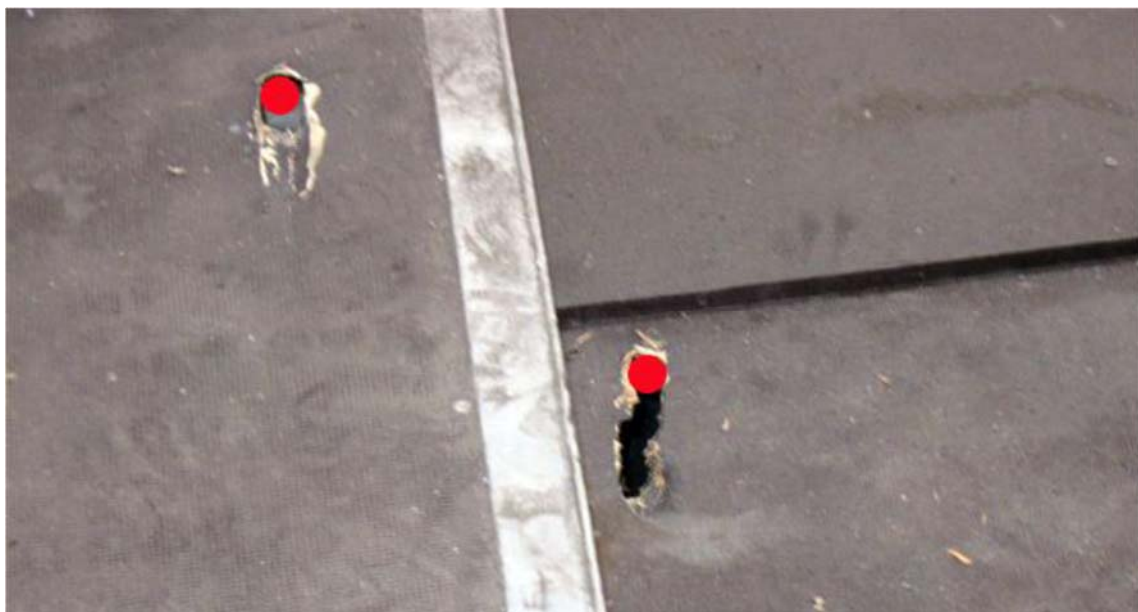
Refer also to Section 26.

## 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 weather proof 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.

Plate 12 to Plate 15 provide details of two separate incidents where the protection arrangements proved to be inadequate risking injury to those below.



**Plate 12: 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*

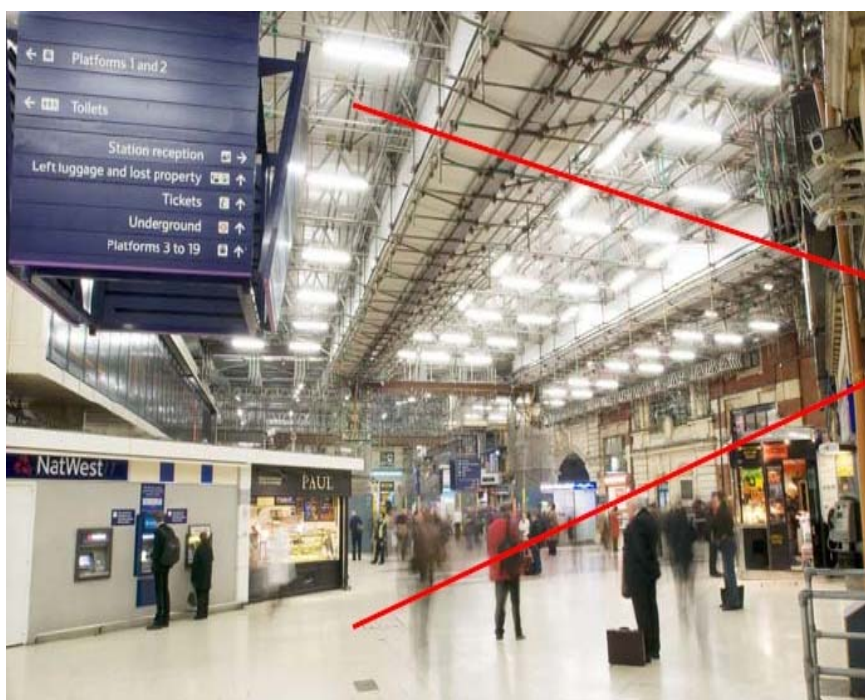


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*operational. There were no injuries however the safety implications were very significant. The incident led to a review of the protection deck design and working practices with associated delay and disruption to the project.*



**Plate 13: Operational Station with Suspended Protection Deck.**



Scaffold tube  
fell from here  
and landed  
here

**Plate 14: Station roofing works.**

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*During a station re-roofing project, a scaffold tube fell from here to here through a gap in the protection deck (see Plate 15 below). The tube narrowly missed a 9-year-old boy, then rebounded and struck a 6-year-old girl*



**Plate 15: 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.

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- 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 must 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 requiring to undertake earthing and bonding on electrified lines the following shall 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 shall apply

The requirements for the design of earthing and bonding systems for 25kV a.c. electrified lines are described in NR/SP/ELP/21085 and PAN 102.

Earthing and bonding is required to ensure a continuous return path for fault currents, and to ensure that accessible and step and touch voltages in excess of acceptable values do not occur. Exposed metal parts of structures and other extraneous metalwork and the like must be bonded to the traction return system.

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This requirement is regularly missed in design submissions for Temporary Works in the vicinity of 25 kV a.c. electrified lines. For example, scaffolding designs are submitted with input only by the specialist scaffolding Designer who may neither be aware of this requirement nor has the expertise. In such instances two separate design submissions, one for civil/structural works, and one for electrification will be required.

There is also a need to update/record bonding arrangements to ensure that Network Rail has current earthing/bonding records. The Contractor should liaise with the Network Rail maintenance representative to agree how to proceed with respect to sourcing, updating, and handing back records.

Design of permanent or Temporary Works in the vicinity of 25 kV a.c. electrified lines, including stations, will need to employ specialist expertise in order to satisfy the requirements for earthing and bonding. For instance, it is important to understand the system and avoid creation of parallel paths in an a.c. environment.

It may be acceptable to bond structures to structures which are already bonded, such as Overhead Line masts. Refer to Plate 16.

#### **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 shall apply

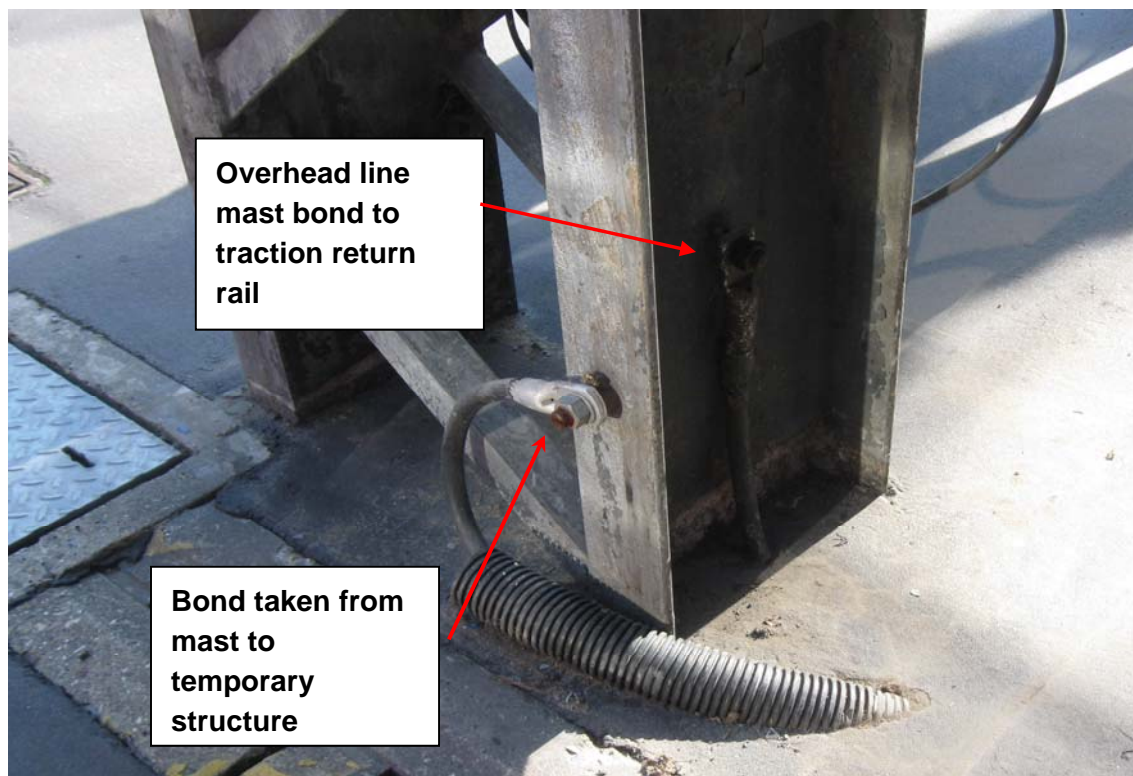
It should be noted that bonding requirements for d.c. 3rd and 4th rail lines are significantly different to those on a.c. lines, the principle being such that structures and extraneous metalwork should remain insulated from and not be connected to the negative return current path. Specialist advice for 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.

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**Plate 16: Bonding**

*Overhead line masts are electrically bonded to the traction return rail. Steel temporary access deck is bonded to the Overhead Line mast. Design and design acceptance are required*

## **Section 24 Gauging and Electrical Clearances**

In areas without OLE the Contractor shall 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 the electrical clearance requirements in GE/RT8025: Electrical protective provisions for electrified lines.

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

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- 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 shall be calculated.

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

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

- a. all Temporary Works are correctly designed for the expected loading conditions and that
- b. 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:

- **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
- **GL/RT/1210** AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

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 these 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 Plate 17 to Plate 19

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Plate 17: Scaffold constructed within 500mm of live overhead line equipment. Remedial works led to delay and disruption



Plate 18: Scaffold constructed within the structural gauge, causing damage to train.

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**Plate 19: 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 20) 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.



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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 the Construction Logistics and Community Safety (CLOCS) or similar schemes to maximise construction safety.



Load moved from upright position



Contact point with Injured Person

**Plate 20: 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 mis-use 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 must 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.

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

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

One example is the use and occasional mis-use 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 to 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.

Refer also to Section 21.

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

## **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.

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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 must 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 must review methodology and if appropriate propose an alternative Temporary Works design.

Examples of lack of compliance with the above are illustrated in Plate 21 to Plate 23.

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**Plate 21: 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 22: Stafford trench collapse due to no temporary shoring.**

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*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 23: 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 24).

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 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 25).

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**Plate 24: 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 must be calculated, monitored and managed in accordance with NR/L2/TRK/001/mod14

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**Plate 25: 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 design and track monitoring regime had been approved.
- 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.
- 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 Demolition and Dismantling**

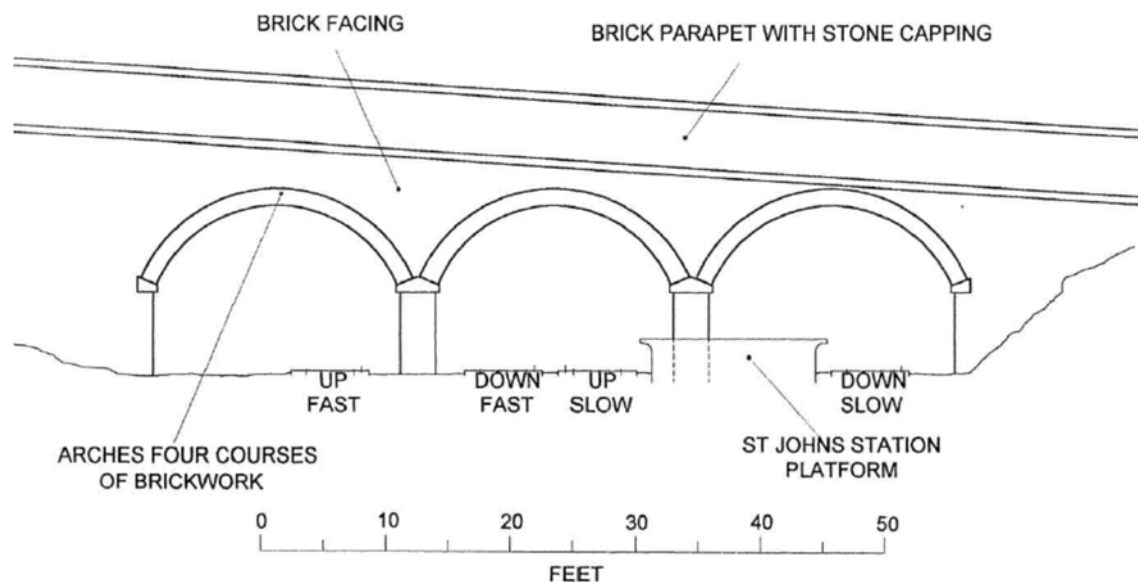
All alteration, demolition and dismantling work should be carefully planned and carried out by competent people to avoid unplanned structural collapse. Demolition and dismantling require a design that incorporates detailed knowledge of the existing structure and how the structure acts.

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 are included in Appendix B and C

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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 26. 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 26: 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 27.



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Lockside Bridge before the incident	Failure of the southern arch during demolition of the centre span
<b>Plate 27 : Lockside bridge collapse</b>	

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.

Temporary Works design (NR/L2/CIV/003/F002 'Statement of Design Intent' and F003 'Certificate of Design and Checking') are 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.

It should not be interpreted from this 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.

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## 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 GRIP Stage 3 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 GRIP 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.

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**PROJECT:** ..... **GRIP 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 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 GRIP stage? If not, what issues need to be addressed?	
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?	

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ISSUE	RESPONSE NARRATIVE
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	
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?	
If the design is compliant with standards is there an alternative non-compliant design which is a good engineering solution which would have safety, Constructability, programme, or cost advantages?	
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	

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ISSUE	RESPONSE NARRATIVE
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, English Heritage, other stakeholders?	
What impact will the works have on surrounding areas? e.g. Noise, dust, light pollution, possible structural movement	
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, noise, etc	
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?	
Is there an alternative compliant design which may offer a safer solution?	
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 the Designer agreed lift size at early GRIP Stage based on Pedestrian Flow?	
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?	

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## **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”

### **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 standard NR/L2/OHS/0047 and associated Forms.

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## **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 may be withdrawn when BS5975:2019 is published.*

## **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.

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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 companies 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 pro forma 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.

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;



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- 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.

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## Appendix C Useful References / Resources

- **NR Safe by Design; Building and Civils Working Group**  
<https://safety.networkrail.co.uk/safety/prevention-through-engineering-and-design/safe-by-design-groups/building-and-civils/>
  - **SbD BC-LSR AideMemoir issue v1.0**
  - **SbD B&C – Rules & Guidance on use of Warning Triangles on Engineering Drawings Issue 2**
  - **B&C Working Group Overview and Status of Workstreams**
  - **The SbD 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** e.g. below listed. Note updated documents can be found at: <https://www.twforum.org.uk/home>.
  - **TWf2012: 01**
    - Hoardings – A guide to good practice; revised in April 2014 (under review at April 2019)
    - First Published - October 2012; Revised - December 2013; Revised - April 2014
  - **TWf2013: 01**
    - Stability of Reinforcement Cages Prior to Concreting Published - October 2013 and
    - Addendum Published - October 2014 also
    - Safety Bulletin: Stability of reinforcement prior to concreting. Published - October 2015
    - NOTE: The guidance on the stability of reinforcement prior to concreting is being revised.
  - **TWf2014: 01**
    - The use of European Standards for Temporary Works design Published - November 2014
  - **TWf2014: 02**
    - Clients' guide to Temporary Works Recommendations for Clients, their representatives, programme managers and others on the design and coordination of Temporary Works. Published – December 2014 –

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- **TW13.032**
  - Differences between permanent and temporary Works
- **UKTWf DL 6PP**
  - Site induction: Guide to Temporary Works
- **TW18.051**
  - Summary: IStructE History of Structural Engineering Study Group – Joint meeting with the Temporary Works Forum; The role and responsibilities of Permanent Works Designers with regard to Temporary Works
- **City University Centre of Excellence**
  - MSc in Temporary Works and Construction Method Engineering
- **TW16.106**
  - The Construction (Design & Management) Regulations 2015 Principal Designer: Guidance on Temporary Works
- **TW16.105**
  - TWf Information Sheet No. 2 Temporary Works Training
- **TWf2019: 01; January 2019**
  - Precast concrete: Good practice and common issues in temporary works
  - <https://www.twforum.org.uk/viewdocument/precast-concrete-good-practice-and>
- **TWf 2019:02, April 2019**
  - Working Platforms: Design of granular working platforms for construction plant - A guide to good practice
  - <https://www.twforum.org.uk/viewdocument/working-platforms-design-of-granu>
- **Generic guidance on safe loading, unloading and transport (Road & Rail) of railway infrastructure materials. March 2012. Published by Network Rail**
- A report on a personnel accident that occurred on 13 June 1992 at St John's in the South Eastern Division of British Railways. HM Railway Inspectorate.
- **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 26 - a series of articles aimed primarily at assisting the Permanent Works Designer with Temporary Works issues
- **National Access and Scaffolding Confederation publications including (but not limited to)**
  - **SG4.15 Preventing falls in scaffolding operations.**

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- TG20:13, Guide to good practice for tube and fitting scaffolding,
- BS5975: - “Code of practice for Temporary Works procedures and the permissible stress design of falsework”
- Network rail “Our Principles of Good Design”  
<https://cdn.networkrail.co.uk/wp-content/uploads/2019/03/Our-Principles-of-Good-Design.pdf>

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## Appendix D Key Points

<b>MAKING A START.</b>	
Collaboration, teamwork, communication.	Let's work together.
Focus and planning.	Thinking ahead.
Competence and expertise.	Right people for the job.
Constructability reviews.	Can we do it better / safer?
Validation of design assumptions.	Share assumptions with all parties.
Early Contractor Involvement. (ECI)	Benefit from practical experience.
Construction sequence.	Critical for safe construction.
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.

<b>DESIGN INTERACTION.</b>	
Lessons learnt.	Consult NR and supply chain databases of lessons learnt and good practice e.g. Safe by Design LL&GP on the collaboration site.
Understand the site.	Shape, levels, geology etc.
Engineering assurance.	Compliance ensures safe design and checking.
Gauging and clearances.	IDC checks vital, as is site monitoring.
Changes to Temporary Works.	Must be communicated to all parties. Must not make ad-hoc changes on site. Change control process.

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<b>THE DETAILS.</b>	
Piling / crane platforms.	Use approved design methods / guides.
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.
Scaffolding.	Qualified and competent Designer, checker & installer.

<b>Taking into use &amp; Handback.</b>	
NR/L2/CIV/003/F005 Certificate of fitness to be taken into use	Ensure this Certificate is completed on site before any significant Construction Work (including Temporary Works) is Taken into Use.
As-constructed records	Ensure as constructed records are accurate and provide details of temporary works required to build, including capture of retained items such as foundations in the CDM H&S File to help with future alteration and eventual demolition
Arrangements for the exchange of asset data and the continuing maintenance of assets undergoing change, (“AMP” process to standard NR/L2/MTC/089)	Comply with Asset Management Plan requirements

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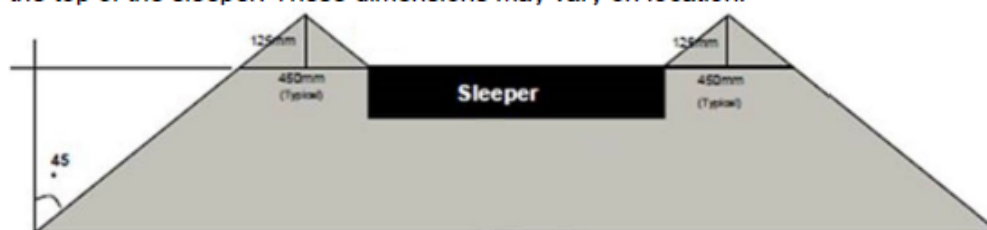
## Appendix E Guidance on the criteria for determining when a Temporary Works Design may be required for excavation near to the track

Guidance on the criteria for determining when a Temporary Works Design is required, in accordance with NR/L2/CIV/003, on projects involving excavations within or adjacent to embankments and cuttings, is shown below. It must be noted that the below is approximate guidance only. It is essential that variables such as ground conditions and embankment/cutting stability are considered by the Designer

The track support zone and zone of influence in Figure 1 is taken from track Monitoring standard NR/L2/CIV/177

### Track Support Zone

The area bounded within a 45 degree plane extending below and beyond the top of the ballast shoulder. The diagram below shows the Track Support Zone, where the ballast shoulder is assumed to have a width of 450mm and a depth of 125mm from the top of the sleeper. These dimensions may vary on location.



### Track System

This is used as a collective term for the parts that make up the permanent way.

*NOTE This term includes rail, sleepers, fastening, ballast and track bed.*

### Zone of Influence

The volume of ground adjacent to building and civil engineering works, which might be affected during construction and their operational life, e.g. through structural instability or collapse.

*NOTE The zone of influence will need to be determined for each project as it will vary depending upon various factors including ground condition and type of building or civil engineering works.*

Figure 1 – Track Support Zone

This states the zone of influence will need to be determined for each project as it will vary depending upon various factors including ground condition and type of building or civil engineering works. **The below guidance shall be read in that context.**

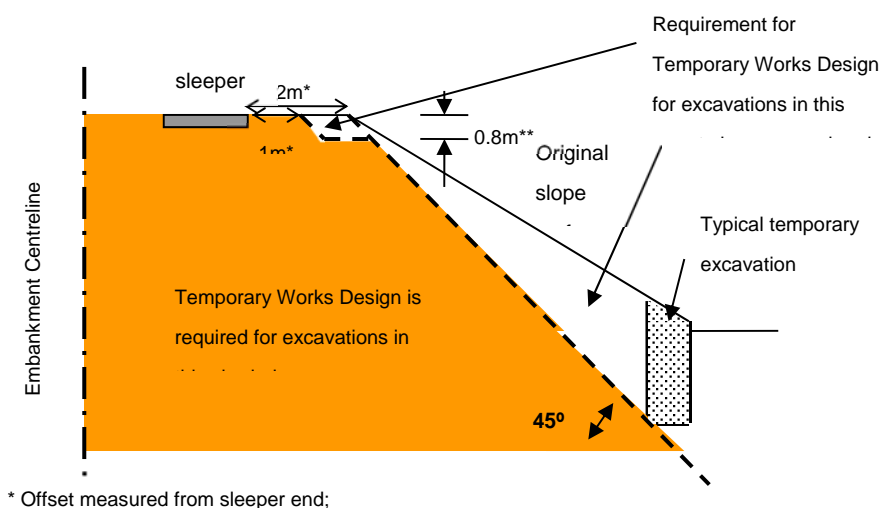
### Embankments

For excavations (except those defined in next paragraph) within 2m of sleeper ends and a 45-degree plane (extending below and away from the cess rail) – a formal Temporary Works Design is normally required.

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For excavations in the cess area beyond 1m of sleeper ends and a 45-degree plane and extending no deeper than 0.8m from top of sleeper – the requirement for a Temporary Works Design should be assessed and recorded in the Design Risk Assessment.

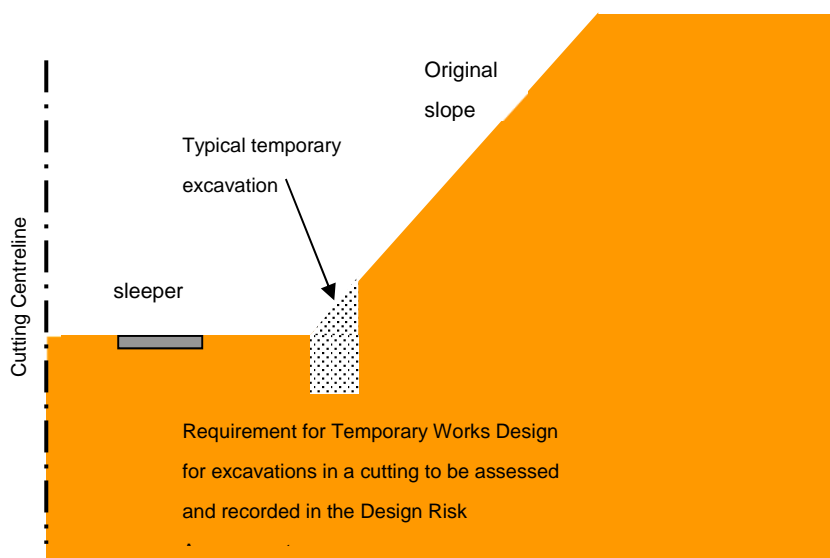
For excavations beyond 2m of sleeper ends and a 45-degree plane (extending below and away from the cess rail) – the requirement for a Temporary Works Design should be assessed and recorded in the Design Risk Assessment.



**Figure 2 - Requirement for Temporary Works Design for Embankment Excavations**

## Cuttings

For all excavations - the requirement for a Temporary Works Design should be assessed and recorded in the Design Risk Assessment.



**Figure 3 - Requirement for Temporary Works Design for Cutting Excavations**



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

The Design Risk Assessment should include an assessment of the required supervision levels and monitoring regime during (and following) the excavation works.

The final decision regarding whether a Temporary Works Design is required will be determined by the Employers Representative.



## Network Rail Infrastructure Projects

*Engineering Directorate*

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