



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

This TWF Guidance is available as a free download from www.twforum.org.uk

Document: TWf2014: 02

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Temporary Works
forum

The Temporary Works Forum (TWf) was formed in 2009 at an open meeting held at the Institution of Structural Engineers in London. The TWf is an independent, not-for-profit company which operates on a limited cost base; its primary asset is the influence of its members in industry, and its primary value derives from its meetings on a quarterly basis and its free-to-access publications (available at www.twforum.org.uk). Meetings are open (contact the Secretary for an invitation) and address issues across the industry.

The TWf works closely with the Health and Safety Executive, and Structural-Safety (www.structural-safety.org). The HSE attend all TWf meetings and some members of TWf are also members of SCOSS (the Standing Committee on Structural Safety, which is a committee of Structural-Safety). The TWf also promotes the use of CROSS (Confidential Reporting on Structural Safety), which is again a part of the Structural-Safety organisation.

Synopsis

This Guide is written to provide clients, and all those with responsibility for construction, with insight into the subject of temporary works. It is set out in five Articles covering risk categorisation, design, design checking, site inspection and temporary works coordination. It is hoped that it is of use to all clients and senior managers, of both large and small scale works, whether they are involved regularly with construction, or seldom, including those whose normal work is not construction but nonetheless find themselves procuring construction works. It expresses mainstream views in the UK construction industry, where temporary works have been delivered relatively well since the Bragg Report (of 1975) and BS5975 (first issued in 1982) introduced the management arrangements which are now prevalent, and are accepted as good practice.

Foreword

The Temporary Works Forum gratefully acknowledges the contribution made by members of the working party in the preparation of this guidance.

Although the Temporary Works Forum does its best to ensure that any advice, recommendations and information it may give either in this publication or elsewhere are accurate, no liability or responsibility of any kind (including liability for negligence) howsoever and from whatsoever cause arising, is accepted in this respect by the Forum, its servants or agents.

Readers should note that the documents referenced in this guidance note are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.

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Acknowledgements

The authors would like to thank those who have supported their work in preparing this Guide. The original concept was proposed by a Client Group formed by Chris Dulake of Crossrail Ltd. During the development of the Guide the contributions and helpful criticism by the members of this Group has assisted the authors to identify key issues to address and key points to make. The Guide has also been reviewed across the Temporary Works Forum membership at two interim stages and the feedback incorporated. The contribution of John Carpenter, former Secretary of the Temporary Works Forum, is gratefully acknowledged.

Purpose of this document

The purpose of this Guide is to assist clients, their representatives, programme managers and other senior leaders in the construction industry¹ in the improvement of risk control and performance on their projects. The opportunities and risks in question are those brought by temporary works^{2,ii}.

Temporary works are often a significant part of a project's construction cost, sometimes 50% or more. Even for simple schemes efficient design, management and installation will radically improve project delivery. A temporary works failure on a project is almost always a high consequence event and may be reportable under RIDDORⁱⁱⁱ.

A significant failure may be catastrophic to budget, programme and reputation as well as to safety; such a failure will bring into question the client's ability to procure and may lead to criminal prosecution, as (inter alia) the client may be perceived to have failed in his duty to employ organizations of sufficient competence³.

This Guide has been written at the request of a group of clients, which approached the Temporary Works Forum. These clients were aware of the risks and, in some cases, the lost opportunities to their enterprises that temporary works present, but felt disadvantaged because they had insufficient insight into the processes at work in temporary works management.

This Guide is written to provide these clients, and all those with responsibility for construction, with a greater insight into the subject of temporary works. It is set out in five Articles covering risk categorisation, design, design checking, site inspection and temporary works coordination.

It is hoped that it is of use to all clients and senior managers, of both large and small scale works, whether they are involved regularly with construction, or seldom, including those whose normal work is not construction but are nonetheless procuring construction works. It expresses mainstream views in the UK construction industry, where temporary works have been delivered relatively well since the Bragg Report^{iv} (of 1975) and BS5975 (first issued in 1982^{4,v}) introduced the management arrangements which are now prevalent, and are accepted as good practice.

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¹For simplicity only the terms 'client' and 'client's representative' are used in the remainder of the text

²'Temporary works' are defined in BS5975:2008+A1:2011ⁱⁱ to be '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'; this Guide asks readers to consider also: 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; this is enlarged upon in the Introduction and in Appendix B

³Refer (inter alia) the Construction (Design and Management) Regulations^{vi}

⁴With the exception of this historic reference, all references to BS5975 in this document are to the edition current at the time of writing, being BS5975:2008+A1:2011ⁱⁱ; this Standard is the UK's prime reference on temporary works and extends to both management procedure and design practice

Introduction: The role of the client

The client is the body for whom the project is carried out. On projects, clients, through the agency of their representatives, set the tone of the project by the appointments they make, the leadership and management behaviours they exhibit and reward, and the balance they set between programme duration, budget, quality and safety.

In defining the role of the client, the Construction (Design and Management) Regulations (CDM Regs)^{vi} give a useful starting point. First, these Regulations set out legal duties. More than that, they give an understanding of best practice which if acted upon will deliver not only health and safety, but also economy, speed and good quality.

With regard to temporary works the most important of the client duties⁵ given in the CDM Regs are:

- Select and appoint a competent and resourced CDM Co-ordinator⁶ and Principal Contractor
- Ensure appointed designers are competent
- Ensure that suitable management arrangements are made for the project
- Ensure that a Construction Phase Health and Safety Plan is produced and that it contains suitable management controls for temporary works
- Ensure sufficient time and resources are allowed for all stages of the project

For a client to be assured that these duties are fulfilled in regard to temporary works, it is natural that the client's representatives will need to know what temporary works are, and what competencies are appropriate.

What temporary works are, physically, is explored in [Appendix B](#). A working definition is given in BS5975ⁱⁱ at Clause 3.40: temporary works are 'parts of the works that allow or enable construction of, protect, support or give access to, the permanent works and which might or might not remain in place at the completion of the works'; the Clause gives examples: structures, supports, back-propping, earthworks and accesses. This Guide asks readers to consider the following also: states of the permanent works which are temporary, loading conditions of the permanent works during construction or project execution which not envisaged in the permanent condition, structures in states of modification or demolition⁷.

However, for the client's role to be fully appreciated we must think also about why temporary works are needed,

and add a more philosophical dimension to this physical definition: temporary works are needed to control the residual risks arising from temporary conditions during project execution.

It is a requirement that risks are reduced 'so far as reasonably practicable' (SFARP). The recommended hierarchy of control to achieve this is by (first) elimination of the hazard (for instance the permanent works are designed in such a way that temporary conditions are avoided), elimination of the temporary works (the permanent works are designed in such a way that no temporary works are required to stabilise or support them in temporary conditions), then substitution (a safer type of temporary works is required or provided), reduction (less temporary works, or at any rate less temporary works at any one time), then lastly design improvement of any temporary works that remain⁸.

While safety principles drive us towards elimination or reduction of temporary works, so too should considerations of cost and time. Temporary works are expensive, take time to design and build, and bring their own hazards.

From these considerations we can see that it is in the client's interest that design teams include people and organisations who have practical and contemporary understanding of the construction process and temporary works appropriate to the works proposed. The design team will then be able to design a solution which ideally eliminates, but certainly reduces and simplifies, the temporary works; for the temporary works that remain, the team can ensure that there are safe and economic solutions, and that the scope and full performance specification for the temporary works are communicated to those who will design and use them.

In seeking to ensure that clients' interests are served with regard to temporary works, their representatives could usefully challenge themselves with the following questions:

- In what way can I be assured that the permanent works design solution is developed to minimise risk from temporary conditions?
- In what way can I be assured that those temporary conditions of the permanent works that need temporary works to control them minimise the extent and complexity of the temporary works, eliminating, substituting and reducing them so far as reasonably practicable to minimise the risk overall?

⁵ *It is a worthy thought that, to identify the requisite actions in these areas and to make them meaningful, the client should first assess his or her own competence to do this, and take steps to make good any lack of competence should it be identified. While the detail of the assessment of competence is beyond the scope of this document, guidance is developed at [Appendix A](#)*

⁶ *It is acknowledged that the proposed 2015 revision of the CDM Regs will replace the role of the the CDM Coordinator with that of the Principal Designer*

⁷ *See [Appendix B](#) for a fuller discussion on what constitutes 'temporary works'*

⁸ *In pursuing these hierarchies it is important that benefits in reducing risks from temporary works (for instance by eliminating them) do not increase risk in another area (for example by making the permanent works erection more risky). There is arguably a 'right amount' of temporary works for a given scheme, which is the amount that reduces the risk overall so far as reasonably practicable; to assess these risks 'overall' requires that the temporary conditions of the permanent works, the construction method and the temporary works themselves are considered as one, collectively*

- In what way can I be assured that the requirements for temporary works will be communicated effectively, with all criteria for performance, including sensitivities⁹?
- In what way can I be assured that the risks from the temporary conditions and temporary works are appropriately allocated and managed, in particular that the temporary conditions and temporary works will be managed competently and safely on site?¹⁰
- In what way can I be assured that the resources deployed (at all stages, including design of both permanent and temporary works) have the competence, time and resources to do the above?
- In what way can I be assured that the CDM Co-ordinator gives due priority to risks from temporary conditions and temporary works?
- How can I be assured that the structuring of the procurement strategy, and the influences that are applied, are not deleterious in any way to temporary works safety?¹¹

The challenges above can be drawn from [Table 1](#), where the evolution of a design for a project is set out. The five Articles into which this document is divided give insight to assist clients and their representatives to pursue these challenges more fully, gauge risk appropriately and understand 'what good looks like'.

The over-riding point is that projects should be designed and resourced to be built safely, efficiently and to the right standard. This is an interpretation of the design-for-manufacture principle of production industries. The resulting benefits of safety, efficiency and quality are worth having, but require a proactive engagement between all parties to the design, construction and operation. By appointing the right parties to the project, making clear their expectations, monitoring performance against these expectations and responding appropriately to professional requests for investment of time and resource, clients, through their representatives, have a key role in shaping their projects for success.

⁹ A 'sensitivity' can be thought of as a particular aspect of the design of the character that if all is done exactly as it should be (given the margins that engineering tolerances allow) all will be fine, but if anything is done even slightly not-exactly-as-it-should-be (for example slightly out of tolerance or not exactly to plan) an incident will result. Sensitivities are the opposite of robustness. Sensitivities introduce risk as even the best performers will step outside the allowable envelope from time to time. As a rule sensitivities should be avoided. However, some designs benefit in the long term from sensitivities during construction. Where this is the case, designers should justify introducing the sensitivity and should ensure it is fully communicated to (including being understood by) the project procurement and construction team. The IStructE publication, *Manual for the systematic risk assessment of high-risk structures against disproportionate collapse*, [reference](#)^x, gives good guidance in this area

¹⁰ The appropriate party will vary according to the risk and is usually held to be the party most able to manage it, which may vary with time. The risks associated with a project need management throughout concept development, design, planning, procurement (by client to advisors, by client to Tier 1 suppliers, and by Tier 1 to Tier 2 suppliers, etc) and execution of the works. Those managing risks need appropriate financial and time allowances and client's representatives should satisfy themselves on this point also, and ensure this consideration is active at all levels of the supply chain

¹¹ For example it is generally harder to achieve temporary works safety if the permanent works are procured as a number of separate works packages, as opposed to a single contract; consider also that a procurement strategy that seeks fees and prices to be at a bare minimum may tend to exclude the broader professional engagement amongst the parties to the works, which this Guide identifies as aiding temporary works safety

Table 1: Sequence of project execution from the perspective of temporary works

Key stage	Primary activity	Temporary works consequences	Temporary works risk action ¹²
Identify need; client decides to develop the project	Assessment, review, asset performance studies		
Fix the nature of the solution	Review possible options ¹³ , design studies	Largely fixes the inherent risks of the project	Identify and thereby (so far as reasonably practicable) eliminate hazards and reduce high risk temporary conditions and states for each option; use findings to inform the nature of the solution; ensure a team is assembled which is competent and resourced to assess and manage the risks
Design the permanent works	Options studies, permanent works design	Completes the fixing of the inherent risks of the project and strongly constrains the methods that can be used to eliminate, reduce and control them; largely fixes the inherent risks of the temporary works	Design the permanent works to (so far as reasonably practicable) eliminate hazards and reduce the risks and costs from temporary conditions and temporary works; set out the information needed to control the significant residual risks; Principal (or Main) Contractor and supply chain to be competent and resourced to manage the risks
Design the temporary works	Temporary works co-ordination; temporary works design & design checking	Completes the fixing of the risks inherent in the temporary works; finalises the methods to control the residual risks of the temporary states of the permanent works design	Follow through on the inform/control of residual risks from above; design the temporary works to (so far as reasonably practicable) eliminate hazards and reduce the risks and costs; set out the information needed to control the residual risks and allocate management responsibility; ensure the temporary works have an appropriate maintenance and inspection regime, and that the design includes safe accesses for this
Execute the temporary works	Temporary works co-ordination; site inspection; control by permits	Monitor emerging conditions to ensure the designs remain relevant; if the design must be changed the full control of the design process must be used	Execute the works in a controlled manner, to ensure what has been designed is what is built; follow through on the inform/control and management of residual risks from above; risk assess all activity, allocate management responsibility and oversee performance; ensure competence of all involved and confirm as adequate the resource level of the team

¹² Risk actions (in order) are to eliminate hazards, reduce risks, inform others of & control the residual risks (the 'ERIC' formula, which is sometimes extended by adding 'protect people and instil disciplines of activity': 'ERICPD'); these may be achieved by eliminating temporary conditions, eliminating temporary works, substituting a lower risk form of temporary works, reducing the amount of temporary works (certainly at any one time), designing improvements to the temporary works and implementing appropriate exclusion zones, processes and protective equipment

¹³ Options studies at this level are beyond the scope of this document. A part of these option studies must be, however, an assessment of the relative hazards. As the options could be of radically different type (for example, infrastructure needs are being met increasingly by control engineering solutions such as variable speed control on motorways which reduces the need to construct new carriageway space) these relative hazard studies are clearly not straightforward, and different alternatives could be safer in some ways but more hazardous in others. This document relates to hazards as encountered when physical works (routinely thought of as building, construction, civil or structural engineering, and involving new build, modification of existing works, demolition etc) are being planned or undertaken. That is not to say that such activities are not encountered across a broad range of industries, as excavation or temporary supports to structures are encountered as much in the power and petrochem sectors, for instance, as they are in a traditional civil engineering context such as motorway or rail construction

Article 1 – Risk Categorisation

1.1.0 Inherent risk

In 1828, Thomas Tredgold gave an influential definition of civil engineering, in which he identified a civil engineer's work to be 'the art of directing the great sources of power in Nature for the use and convenience of man'.

The concept of entropy was not defined at the time, and Tredgold's line of thought might have led him to a slightly different position had it been: the work of a construction professional today, to echo Tredgold's words, can be thought of as being 'to concentrate energy for use and convenience'.

The issue at hand, and the relevance of concentrated energy, is that concentrated energy will tend to disperse and even out with its surroundings in time. The consequences are, for example, that structures we erect tend to fall down, water we hold in a reservoir will tend to break out and flow down, substances we pressurise will tend to break out and disperse, vehicles we constrain to move along tracks or specific paths will tend to come off them and, should they do so, may crash catastrophically.

The first merit of this line of thinking is that by recognising where we have locally concentrated energy we recognise where we have a potential for failure: a hazard. The greater the concentration of energy, the greater is the scale of the potential failure. This guides us in our hazard identification.

The second merit is that by recognising that nature is tending to make things fail, we focus our efforts on ensuring that this does not occur during the planned service life of the works we are constructing. We are, in a sense, playing a waiting game with nature: in the long term the natural degradation of materials will cause our works to fail; in the short term errors or omissions will cause failure during the course of construction work. By taking the position that 'failure is inevitable, the question is when', we never assume that the worst cannot happen. Commentators in the field of forensic engineering regard this to be a healthy state of mind, despite its negativity^{14, vii, viii, ix, x}.

Focussing back onto temporary works we can see that

- Any weight at height will lose height unless prevented (this includes things falling over sideways then down as well as straight down, and the soil forming the side of excavations sliding into the excavation)

- Any materials separating zones of different pressure in a fluid will move towards the area of low pressure unless prevented (pressure differences can be caused by flowing water, wave action, wind etc, and are often normal to the direction of flow)
- Materials will float (or partially float, losing interface friction) if water levels rise, unless prevented
- Any forced segregation of fluids will mix unless prevented
- Any forced concentration of fluids will disperse unless prevented
- Any forced combination of materials will separate unless prevented
- Any pressurised fluid will leak out unless prevented
- Any volume under pressure will expand unless prevented
- Where we are alongside high energy sources, accidentally interfering with them can cause problems which are disproportionate to the failure we are managing directly (for example a hoarding, if blown over, could fall onto a road or railway line and cause a major incident)

The construction industry serves our society's need for tall structures, underground structures, energy efficient high pressure and high voltage fluid and electrical systems, high speed transportation, containment of dangerous but useful chemicals, and so forth. These needs create inherent risk in the form of large masses at height, high pressure, high voltage, high kinetic energy, huge masses of soil either side of deep excavations, extreme concentration of toxins and so forth.

We should bear in mind that all structural materials (eg steel, concrete, timber, even rock) require a concentration of energy (whether through their manufacture or by natural process) and will therefore tend to degrade. This degradation can be the trigger for failure at a much bigger scale.

The risks in the operational phase of a facility will be identified through hazard studies. Often less attention is given to the construction phase, but these facilities cannot be wished into place: they must be methodically constructed, stage by stage. The inherent risks in the temporary conditions are much the same as in the permanent condition (the loads, potential energy and so forth are the same, as are the potential impacts on adjacent assets) but there are added difficulties with temporary works, both

¹⁴ See, for instance, *Henry Petroski To Forgive Design*^{vii}, *Weick and Sutcliffe Managing The Unexpected*^{viii}, *Sir Charles Hatton-Cave's address to the Institution of Civil Engineers on 19 November 2013*^{ix} and the *IStructE's Manual for the systematic risk assessment of high-risk structures against disproportionate collapse*^x, which gives a highly practical methodology for risk management

- inherently:
 - the materials used must be handleable, often man-handleable
 - the temporary structures must be self-stable as well as supporting the permanent works in temporary conditions
 - as the temporary structures are designed (usually) for a known and one-off load, they are highly stressed in service
 - access must be provided for construction personnel, and prevent falls of them, their tools, small parts, etc
 - the site configuration is constantly evolving
- and from the prerogative for efficiency and economy:
 - the use of standard equipment, used many times
 - structural forms which are often highly indeterminate, but are nonetheless of a type that a single seemingly insignificant component can be critical to the stability of the whole
 - the time and cost pressures arising from the contractual circumstances

Perhaps the one saving grace is that temporary works are (in many cases) loaded under the supervision of the teams that design and build them. However, even this cannot be relied upon.¹⁵

What are required for the safe management and execution of temporary works are communication, co-operation, co-ordination and competency at the highest level, and an overriding culture of mindfulness.¹⁶

1.2.0 Risk categorisation

This Guide recommends that temporary works are categorised for risk according to:

- Consequence of failure (should it occur)
- Design complexity
- Execution criticality

1.2.1 Consequence of Failure Risk

The consequences of a failure can be radically different according to circumstances. The failure of a minor excavation in a remote location for a task which requires no man-entry (CFR0 or CFR1) is different entirely from a similar excavation failing such that it undermines a main line railway or pressurised tank of noxious chemicals (CFR3). In essence, the Consequence of Failure Risk requires consideration of what could happen if things go wrong, bearing in mind that we should never think that the worst cannot happen.

Four categories of Consequence of Failure Risk are proposed, see Table 2.

Consequence of Failure Risk (CFR) therefore springs from the nature of the works to be carried out, the location of the works and what is in proximity such that it might be affected if failure of the temporary works occurs. This may be time dependent.

A number of parties need to give consideration to Consequence of Failure Risk, for instance:

- Clients and their Representatives (for example when establishing the basis of risk control and ensuring the competence of key parties)
- Permanent works designers and the CDM Co-ordinator (for example when determining site location, the nature of the works to be constructed, and when assessing risk potential within a site)

Table 2: Categories of Consequence of Failure Risk

Category	Characterisation of consequence of failure
CFR0	benign, no impact if it fails
CFR1	low impact and entirely within site; inconvenient but personal injury unlikely
CFR2	potentially major effect, but failure, while potentially of major impact (for instance involving fatalities and injuries +/- significant economic loss) would not initiate any secondary or chain reaction of major incidents
CFR3	failure, should it occur, would be catastrophic in its own right or, even if minor in its own right, might initiate a secondary or chain reaction of major or catastrophic incidents

¹⁵ Appendix D explores this topic further

¹⁶ See Appendix A and Reference^{viii}

- Adjacent asset owners (they should be involved as they have best knowledge of potential risks should temporary works failure have influence beyond the site boundary)
- Principal and Main Contractors, subcontractors and their respective teams including in particular the Temporary Works Coordinator (for example when determining methods and sequences of construction and carrying out works)
- Temporary works designers (for example when developing temporary works solutions)

1.2.2 Design Complexity Risk

Design Complexity Risk (DCR) is treated, in effect, in BS5975ⁱⁱ. The Standard does this by recommending four Categories of design checking regime (0, 1, 2 & 3) as the risk control. This Guide endorses this principle and adopts the four Categories, but adds two more: Category 00 and Category 4.

Category 00 is for temporary conditions, items or structures which can be safely managed by

competent persons in competent site teams, without design, by following custom and practice and an industry standard safe system of work. Such parts of the works might include kicker shutters, shaping of the ground and so forth. The safe system of work will normally include risk assessments which focus on the operation at hand in its context, method statements and supervision. It is a useful category in that it allows professionals to talk meaningfully about types of work that are temporary, but without evoking the full management processes of BS5975, which, in the circumstances, would add bureaucracy without any practical benefit.

Category 4 is for temporary works which have abnormal and highly innovative designs, beyond the scope of normal design codes and practices.

This Guide also recommends that Consequence of Failure Risk (Table 2) is a factor which should be taken into account in considering Design Complexity Risk; six Categories are recommended, see Table 3.

Table 3: Categories of Design Complexity Risk

Category	Characterisation of design ¹⁷
DCR00	temporary conditions, items or structures which can be safely managed by competent persons in competent site teams, without design, by following custom and practice and an industry standard safe system of work, provided Consequence of Failure Risk is CFR0 or CFR1 (Table 2 refers)
DCR0	standard solutions ¹⁸ provided Consequence of Failure Risk is CFR0 or CFR1
DCR1	simple designs provided Consequence of Failure Risk is CFR0 or CFR1
DCR2	more complex or involved designs provided Consequence of Failure Risk is CFR2 or below; also designs with Design Complexity Risk DCR00, DCR0 or DCR1 either with Consequence of Failure Risk CFR2 or where there is interaction between adjacent but separately managed schemes ¹⁹ (or both)
DCR3	complex or innovative designs which result in complex sequences provided Consequence of Failure Risk is not CFR3
DCR4	abnormal and highly innovative designs beyond the scope of normal design codes and practice; also any scheme with Consequence of Failure Risk CFR3

¹⁷ For categories DCR0, DCR1, DCR2 & DCR3 refer BS5975 Table 1 Categories 0, 1, 2 & 3; in BS5975 'standard solutions' are defined: 'a suitable arrangement of components for which the basic design work has already been carried out and is presented in a tabular or other easily assimilated form, and for which no further structural calculations are necessary'

¹⁸ It is the authors' experience that relatively few schemes are Design Complexity Risk category DCR0 in their entirety; even routine schemes need foundations, and interaction with natural earth can seldom be a 'standard solution' in the definition of BS5975 (see footnote¹⁷ also)

¹⁹ see footnote¹¹ also

With these additions, adding to a précis of BS5975, Table 3 has been developed.

Examples are discussed in [Appendix C](#). The design and design checking procedures in respect of these categories are set out in [Articles 2 & 3](#).

EuroNorms

At the time of writing, EuroNorms present a special case of design complexity. As a generality they have not been written with temporary works in mind; [Appendix D](#) illustrates why this is relevant. In addition, some parts of the temporary works industry are having difficulty with their use, largely because they are complicated in their structure, as, typically, many separate documents must be referred to, to develop just one design. The Temporary Works Forum has published documents on this subject (see, for instance, Jones et al 2014^{xi}). BSI is planning PAS 8811 to take the issue forward.

In assessing risk, if EuroNorms are to be used, it would be prudent to consider increasing the DCR category, depending on the competence of the team.

1.2.3 Execution Risk

Execution Risk (ER) is a measure of the propensity for failure resulting from issues related to use, workmanship and/or materials. Execution Risk is therefore influenced by design but its management and control requires appropriate care and attention both in materials procurement and on site, at all stages of erection, assembly, use, operation, maintenance, disassembly and removal. This Guide proposes four categories, see Table 4.

It is considered essential that temporary works designers make clear in their design output the controls and hold points they consider necessary to ensure the Execution Risk can be adequately managed by those procuring, constructing, using and removing the temporary works. Of course, further controls and hold points may be added by the construction teams.

1.2.4 Managing Consequence of Failure, Design Complexity and Execution Risks

In all cases, all involved should seek to eliminate foreseeable hazards to the health and safety of those affected and to mitigate those risks which cannot be avoided.

The three types of risk identified (Consequence of Failure, Design Complexity and Execution Risk) should be actively managed and reduced throughout the design process. The permanent works design phase gives the greatest scope of opportunity: once the permanent works scheme is chosen, the Consequence of Failure Risk is effectively fixed, and the scope to reduce Design Complexity Risk and Execution Risk becomes limited.

Throughout the planning, design, procurement and construction phases a formalised risk management procedure should ensure the clear allocation of responsibility for risk management. Such a procedure will ensure that risks are addressed adequately by the appropriate party, with appropriate financial and time allowances.

The level of Consequence of Failure Risk, with explanation, should be given in the Temporary Works Brief. This information will be important to the Temporary Works Co-ordinator, and to the temporary works design, design checking, procurement and operations teams. See [Articles 2, 3, 4 and 5](#) below.

To allow Consequence of Failure Risk to play its part, while keeping the document simple, it is assumed, where there is high Consequence of Failure Risk, that designers will increase the category of Design Complexity Risk, and operations teams will increase the category of Execution Risk. Suggested adjustments are given in [Tables 3 and 4](#) below

Table 4: Categories of Execution Risk

Category	Characterisation of the propensity to failure during erection, assembly, use, operation or removal
ER0	no identified practical mode of failure, and Consequence of Failure Risk is CFR2 or below even if it did fail
ER1	minor structures with high levels of robustness and redundancy provided Consequence of Failure Risk is not CFR3
ER2	conventional structures provided Consequence of Failure Risk is CFR2 or below
ER3	schemes with dependency on critical structural details or tension details, or with little or no redundancy or with inherent instability; also any scheme with Consequence of Failure Risk CFR3

Designers (both temporary works designers and permanent works designers) have the opportunity to eliminate hazards and mitigate risks and inefficiencies by design. As a generality this implies that all requirements for temporary works should be minimised. Where temporary works are required, the design should be developed to minimise the categories of Consequence of Failure Risk and Execution Risk.

Those on site have the opportunity to eliminate hazards and mitigate risks by practical means, especially by ensuring control and good quality workmanship, and by using methods that minimise the exposure of personnel to hazardous environments.

1.2.5 Other risks

This Article has focussed on specific aspects of the risk management of temporary works from the perspective of the works themselves: what is their situation, what is their complexity, how critical is their workmanship. In parallel with this must be a consideration of the other generic risks arising, for instance from the competence of the people involved and the quality of the processes used (for example to design, to check, to review, to procure, to validate software etc). This is illustrated in the IStructE publication 'Manual for the systematic risk assessment of high risk structures against disproportionate collapse'^x.

Article 2

Good Temporary Works Design

2.0.0 Introduction

Good temporary works designs are characterised by the following:

- they are simple and safe to fabricate, erect, check once erected, use and remove; careful thought has been given to these matters
- they are each a single, fully co-ordinated design in which all relevant aspects of the structural system are considered²⁰
- they are robust and are sufficient as structures in their own right; also they have safe access for inspection and maintenance and, where needed, an appropriate inspection and maintenance regime
- the designer's intent is communicated fully and without ambiguity
- the basis of each design is clear to those who will manage each individual scheme, and to those who will manage the overall project, so that they will identify and pay proper attention to the safety and performance-critical features; they will know and respect all sensitivities of the design; they will know what changes in circumstances would invalidate the design

Good design requires a considered, early appointment and briefing of the designer. A good appointment will be based on sufficient knowledge of the design work to be conducted: in principle the designer needs to know what has to be done and be comfortable that the time, resources and budget are available to do it. If it is not possible to achieve this position at the outset, a two-stage (or multi-stage) process should be used to agree scope and price progressively. A good appointment will ensure that the designers who will undertake the work are suitably qualified and experienced, and that they are properly supported by the management processes of their organisation; the design organisation, as well as individual designers, must be competent in the type of work^{21, xii}. Early temporary works designer appointments will maximise the

designer's contribution to the design concept and ideally to the design of the permanent works, so that the permanent works scheme is adapted to a safe, efficient construction methodology and temporary works. A formal peer review of the permanent works concept, involving construction method and temporary works experts, will normally pay dividends²².

The majority of temporary works are designed during the construction phase of the project. In some circumstances the temporary works will be designed by, or on behalf of, the Principal (or Main) Contractor directly. In many circumstances, the temporary works designs will be prepared by, or on behalf of, sub-contractors whose sub-contract package includes temporary works design. In all cases, the temporary works designers may be internal or external to the organisation with contractual responsibility for the works themselves. Where design is procured as a part of a broader sub-contract, clearly the ability to deliver a competent temporary works design is a prerequisite for appointment.

It is relatively rare for clients and programme managers to commission temporary works design before the construction phase. More normally they will be seeking construction advice in a broader sense. If a client or programme manager does wish to commission temporary works design, unless they have specific expertise in temporary works, it is as well to engage a design practice which specialises in temporary works, and ask them to coordinate the temporary works for the period until the Principal (or Main) Contractor is appointed. The Temporary Works Forum (www.twforum.org.uk) can advise of such practices, which tend to be SMEs²³. Another course of action is to engage a suitable contractor to provide pre-construction advice.

BS5975ⁱⁱ, at Sections 8 & 9, sets out the industry standard processes for design briefing and the design of temporary works. The text that follows here adds to this, and is set out in 4 parts: design brief (2.1), concept design (2.2), detailed design (2.3) and site support (2.4).

²⁰ This must be achieved even where various parts of a single structure are prepared by different designers, or there are independently procured but interacting structures. For instance a falsework may be designed by an equipment supplier but stand on a suspended slab designed by the permanent works designer, be stabilised in sway by columns in a temporary condition which is the design responsibility of the concrete frame contractor, and have a timber deck designed by a fourth party; it is possible that lateral stability develops a load path to a neighbouring site, or ground support introduces soil stresses beyond the site boundary. See Article 3 on design checking and Article 5 on temporary works co-ordination. While designers should take a holistic view, this is not always realistic given the current procurement structures and commercial pressures in the UK industry. Clients and their representatives should consider if their procurement strategies tend to enhance or be deleterious to considerations of this type

²¹ See Approved Code of Practice (ACoP) to CDM Regs 2007, App 4, Reference^{xii}

²² See SCOSS document References^{xiii & xiv}

²³ SME: Small and Medium Sized Enterprise

Where a client body has its own rules for temporary works design and management, it should ensure that its rules align with best practice. An audit against BS5975 and this document would be a means to do this. The rules, wherever they depart from BS5975, add to it or introduce specific requirements, should be made clear in any brief. Also, as a matter of convenience, client body rules should strive to use common terminology and processes, as single design and contracting organisations typically work for many clients at the same time.

Clearly, as design complexity increases, refer [Table 3](#), the detail of the design process varies, becoming more and more rigorous; BS5975 and the text below refer.

A particular type of hazard emerges where the permanent works are procured as separate packages, or there is adjacency of neighbouring sites. This type of situation must be handled with particular attention as, while the schemes may be commercially independent, the structural stability of their temporary works may not be, and structural forces give no regard to commercial boundaries.

2.1.0 Design Brief and Design Statement

2.1.1 Design Brief

This section applies to Design Complexity Risk category DCR0 and above ([Table 3](#) refers). DCR00 does not require a design brief.

BS5975, at Section 8, sets out clear requirements for the Design Brief, and, at Section 7.2.5(d), that the TWC (Temporary Works Coordinator) is to ensure that it is 'prepared with full consultation, is adequate and is in accordance with the actual situation on site'. It is preferable for the temporary works designer to be involved in the development of the brief.

The Design Brief sets out the performance and other characteristics required of the temporary works and the information which is to be used to progress the design. This underlying basis for the design must be understood by others so that they can confirm that the design remains valid at the time at which it is used.

A Design Brief is required for all Design Complexity Risk categories DCR0 and above. Clearly, however, the content and detail will vary, involving relatively little work for a small and low risk scheme, to a large amount of information for major work. BS5975 is clear on this point (BS5975, Section 8.3). The TWC is to ensure that the Design Brief is adequate, and may rely on personal judgement, or seek advice.

Attention is drawn to the following points:

- What constitutes 'a design' needs careful thought. A pitfall to avoid is to break one scheme into parts and to fail to recognise interdependencies between the parts; interdependencies may be structural, or may result from proximity in location, time or sequence. Where projects include temporary works solutions prepared by a number of temporary works designers or contractors, it is essential that they are adequately coordinated, which is the duty of the Temporary Works Co-ordinator appointed by the Principal (or Main) Contractor.
- All design briefs should indicate the Consequence of Failure Risk ([Table 2](#) refers). If the Consequence of Failure Risk is Category CFR2 or CFR3, the Design Complexity Risk should be raised ([Table 3](#) refers)
- It is insufficient for the temporary works designer to be given access to a database and be expected to search for the relevant information; while stating what information is available for reference and where it can be found, the design brief must be specific as to the information to be used
- The temporary works designer requires a wide range of information (BS5975, Section 8, refers). This may require more or different information than is provided in the contract documents or is otherwise available; occasionally new information may be needed which, in some cases, might be simply to confirm the accuracy of the existing information. Information about adjacent schemes may be needed which, whilst the schemes are commercially independent, their temporary works are not. The temporary works designer must review the information and, using independent judgement, assess that it is current and sufficient, or, if not, request additional information as required. All requests made by the temporary works designer for additional or confirmatory information should be passed to the TWC for action, and must be honoured
- Working from the design brief, and by visiting site if appropriate, the temporary works designer will make a thorough review of what is in the location of the proposed temporary works, or is close enough to affect them, or be affected by them, or may at some stage come close enough. These things may include soil conditions, excavations, other temporary works, fixed assets, vehicles passing, crowds,

water, etc. How these influences on the design affect it must be clear from the brief. Where not initially clear, the temporary works designer will conclude the matter with the TWC and make it clear by updating the Design Brief, or the Design Statement or other documents as relevant

- The Design Brief must convey to the temporary works designer a full understanding of the purpose of the temporary works, including the criteria they must fulfil, for example, in respect of loads and stiffness, any spatial constraints, the criteria that the temporary works must fulfil in the way in which they interact with the permanent works and any relevant sensitivities²⁴ of the permanent works solution. Where appropriate the permanent works designer should be used by the TWC to brief the temporary works designer directly; clients must ensure that permanent works designers are enabled to do this
- The temporary works designer must be briefed on any preferences and constraints on the materials or components to be used, their delivery and handling; site access and crane handling capacity might also impose constraints
- BS5975 makes it clear that the temporary works designer must be briefed on programme and timing issues; it is germane to make the temporary works designer aware also of risks and opportunities in this regard
- The design brief must make clear the requirement for safe accesses for inspection and maintenance and call for a maintenance schedule

2.1.2 Design Statements

This section applies to Design Complexity Risk category DCR1 and above (see Table 3), supporting BS5975, Section 9.1.3.

The Design Statement is a counterpart to the Design Brief, as together they set the basis for the design work. The Design Brief is written to confirm site specific information and performance requirements; the Design Statement is written to confirm the technical basis for design. The Design Statement is normally written by the temporary works designer.

BS5975 suggests the use of a 'design statement' for 'complex schemes'. This Guide suggests that a 'complex scheme' would be one of Design Complexity Risk category DCR1 or greater. Certain client bodies call for these types of documents, for example the Highways Agency's 'AIP', Network Rail's 'Form 2' and 'Form 3', and London Underground's 'Conceptual Design Statement'.

BS5975 identifies the following content for a Design Statement:

- The various loads that will act on the structure together with the combinations in which they will be considered
- Relevant British Standards or other documents used in the design process
- An idealised structure
- Method(s) of analysis
- The version of computer software, if any, used
- Limitations and assumptions

2.2.0 Concept design, options studies and concept peer review

With the Design Brief and Design Statement confirmed, the designer can work up the design itself. This may start with a concept design, which is to test that emerging proposals meet requirements.

For a complex design, the temporary works designer will take the concept through the following stages:

1. Work up and record initial concepts
2. Review appropriate concepts with his or her client (usually the site team), and shortlist
3. Review the shortlisted concepts with the permanent works designer
4. Select preferred concept
5. Peer review and then update the selected concept as appropriate; agree across the team that the chosen concept is fully appropriate
6. Sign off the chosen concept with the permanent works designer
7. Sign off the chosen concept with his or her client (usually the site team)

²⁴ See footnote⁹

Table 5: Recommended concept design activities in relation to Design Complexity Risk

Design Complexity Risk	Minimum concept design activities from list 1-7 (see 2.2.0)
DCR00 (refer Table 3)	Nil
DCR0	Nil
DCR1	7
DCR2	1, 2, 4, 6, 7
DCR3	1, 2, 3, 4, 6, 7
DCR4	All

The peer review process is explained in SCOSS documents 'Independent review through peer assist'^{xiii} and 'Appointment of independent reviewer through peer assist'^{xiv}.

Not all stages are required for all Design Complexity Risk Categories, as set out in Table 5.

2.3.0 Detailed design

All temporary works of Design Complexity Risk Category DCR0 (refer Table 3) and above require design. However, not all parts of this section apply to all categories of design; what is required is clarified in the text below.

2.3.1 Structural system

This section applies to Design Complexity Risk category DCR0 where the scheme is large, and to all schemes DCR1 and above.

A diagram at the start of the design documents will set out the structural system contemplated by the designer. It will show:

- where loads are applied or developed, and their magnitude
- the load paths to the point at which they are considered to be fully taken to ground and dispersed, or carried to a support of sufficient strength, stiffness and robustness²⁵
- the degree of fixity in joints
- where continuity is assumed
- how stability is achieved²⁴
- what reliance is placed on permanent works elements or existing fabric²⁴
- key assumptions affecting load and strength such as barriers used to prevent impact loads,

water flow speeds, wave characteristics, dewatering levels

- foundation characteristics
- any critical sequences, for example that one part is loaded first in order to give stability as the work continues

2.3.2 Calculations

This section applies to Design Complexity Category DCR0 and above.

Documentation will be prepared which shows clearly how every component and connection of the entire structural system has been justified for the use to which it is being proposed. The justification must identify and address the most onerous load case for the component in question. This may not be obvious and errors have occurred over the years from failure to consider, for example, wind uplift on decks before concrete is poured, stresses during handling or dismantling, unbalanced loads on members during the construction sequence, wind causing overturning of empty silos, interim stages of excavation and so forth.

The justification may include

- demonstrating that proprietary components are used in accordance with suppliers' instructions and load charts
- calculations to justify non-standard or generic components, or non-standard uses of proprietary components
- where appropriate, incorporation of design by others

²⁴ See footnote⁹

²⁵ Assessing what constitutes a support of sufficient strength, stiffness and robustness requires experienced judgement, particularly as deflections of the support can cause effects which a consideration of the two parts in isolation from one another will not detect. Designs from suppliers of proprietary equipment (eg falsework, access, craneage) are normally presented on the assumption that whatever they bear onto is adequate, and the supplier's documents carry due caveats. This places the onus onto the Principal (or Main) Contractor to ensure that the supporting medium is adequate. Where the supporting medium is the permanent works, the permanent works designers should be duty bound to confirm that the permanent works are adequate for the temporary use proposed

The codes used and software (if any) will be made clear. Caution is needed when using combinations of codes which are not explicitly intended to be used together. Great care must be taken to avoid mixing limit state and permissible load approaches and, when a limit state approach is used, to avoid mixing the different limit states. In cases where designers are using EuroNorms, but are unfamiliar with them, additional care should be taken ([see 1.2.2 above](#)).

Computer calculations should be supported by order-of-magnitude hand calculations.

Industry standard methods will be used unless there is good reason not to, in which case the reason should be given.

2.3.3 Design drawings

Drawings will be prepared which clearly communicate the general arrangement and all details. The level of detail must be sufficient to prevent misinterpretation or ambiguity leading to error in fabrication or erection. Acceptable tolerances must be stated, either explicitly or by reference to codes. Significant residual risks will be highlighted – a yellow hazard triangle with attendant note is often used on the drawings (albeit it is recommended that this technique is used sparingly to retain impact and to avoid obscuring the drawings). Issues might include soil conditions, water levels, sequences, clearances, robustness of existing fabric where incorporated into the structural system, etc.

Wherever practical, the permanent works drawings should be enhanced to co-ordinate with the temporary works drawings. For instance, where the temporary works need inserts cast into the permanent works, additional reinforcement bar or other features, these should be shown in the permanent works drawings and schedules. Clients and Programme Managers should ensure that their briefs to permanent works designers include for them to add these details where requested by the temporary works designer.

Where BIM modelling is used, temporary works features which remain embedded in the permanent works should be included as a minimum, 'so that, on completion of construction, the model is a full representation of what is there. It is worthwhile also to at least space plan (within the model) the temporary works which are removed, as a further step to aid planning. Ideally the temporary works will be themselves fully modelled.

2.3.4 Sequence drawings

Where appropriate, the temporary works designer will prepare drawings showing critical stages or sequences of work, identifying when

Hold Points are needed. These sequences may apply to the temporary works themselves or (more usually) to the sequence of permanent works construction.

2.3.5 Specification

Where appropriate, the temporary works designer will prepare a specification to accompany the design drawings, so that the technical specification and workmanship requirements of each significant component and assembly are known.

The specification will include an inspection and maintenance schedule wherever inspection or maintenance is foreseeable.

In simple cases, notes on the drawings provide an adequate format for the specification.

Where BIM modelling is used, the specification of each object can be provided as meta-data linked to the object.

2.3.6 Elimination of hazards and reduction of risk during design

The CDM Regs set out, in Regulation 11, the duties of designers in respect of the elimination of foreseeable hazards and the reduction of risk that remains (so far as reasonably practicable), coupled with the provision of information in respect of those significant residual risks which would not be evident to a competent contractor. In accordance with Regulation 7, designers are required to apply the general principles of prevention and protection. Safe accesses for inspection and maintenance must be detailed.

The greatest opportunity to eliminate temporary works risk comes prior to and during permanent works design. To this end, this Guide strongly recommends that clients engage temporary works and construction method specialists in the early stages of the design development of the permanent works.

Once the permanent works scheme is set, the temporary works designers are constrained to design temporary works that allow the permanent works to be constructed. Should the constraints be such that the temporary conditions or temporary works have high risk (for example fall into the highest categories of Consequence of Failure, Design Complexity or Execution Risk), it is good practice for the designers to record the hazard elimination and risk reduction process that they have undertaken. Firstly this process will motivate hazard elimination and risk reduction; secondly it will be of use later should the diligence and competence of the designer in this aspect of design be challenged. This recommendation applies equally to permanent designers (how have they

eliminated hazard and reduced risk from the temporary conditions and temporary works that inevitably result from their design) and temporary works designers (how have they eliminated hazard and reduced risk given the constraints set by the permanent works design). Those who set other constraints (for example of budget and timescale) should consider the impact of their decisions likewise.

Where the Consequence of Failure Risk is category CFR2 or CFR3 there is a potential for a catastrophic incident. In these circumstances both permanent and temporary works designers must consider this heightened risk profile and be able to demonstrate how their design work has been developed accordingly.

For all schemes where the Consequence of Failure Risk is category CFR3, the Design Complexity Risk is category DCR4 or the Execution Risk is category ER3 a peer review is appropriate both during concept design and towards the end of the design phase. The SCOSS documents [References^{xiii & xiv}](#) outline the process. The peer review should involve key members of the procurement and site operations teams, so that they can assist to further reduce risk and also get familiarity with the design, its sensitivities and its residual risks. Peer reviews may be appropriate for other categories of risk, at the discretion of those in control of the risk management process.

2.3.7 Communicating residual risks to procurement and site operations teams

The designer is duty bound to communicate the significant residual risks that may not be obvious to those using the design. This applies to all categories of design, and to both permanent and temporary works. The way in which this is to be done should be set out in the project risk management processes^{26, xv}. A project Risk Register and Temporary Works Register (BS5975 refers) should be seen to be minimum requirements.

The most valuable form of communication is a good quality document package, comprising drawings, details, specifications and a Design Statement which are clear, accurate, unambiguous and project specific. The permanent works designer should provide these documents for the permanent works, so that the temporary conditions, the required temporary works and their performance specification are clear to the Temporary Works Co-ordinator

and temporary works designers. From these documents a competent site team will be able to put in place an appropriate safe system of work including (inter alia) clear and understandable risk assessments, method statements and work instructions.

Building on good quality documents, face-to-face briefing is a good form of communication. This could be a toolbox talk or site briefing for simple schemes. More complex schemes warrant more formality. As stated above, a formal peer review involving the procurement and operations teams is a useful part of the process for the highest risk schemes, and will aid communication. BIM and virtual reality processes can also provide excellent opportunities for communication, in particular to allow the construction method to be rehearsed.

Notwithstanding face-to-face briefing, documentation of significant residual risks is required. All projects should have a formal Risk Register. For simpler schemes a single line item on the Risk Register may be sufficient, identifying that temporary works are a risk – specific risks can then be noted on the drawings. For complex and high risk schemes, temporary works items should be itemised in the Risk Register and the risk control measures robustly treated in the document set.

While many designs (both permanent and temporary works) are inherently robust, that is to say if one part fails the consequences are minor, other designs, or features within the design, may not be. They are 'sensitive'²⁷ and fall into Execution Risk categories ER2 and ER3 (see [Table 4](#)). In these cases the designers should identify the control measures they consider need to be applied to control the risk.

In preparing the temporary works design, there are often safety, stability or performance critical assumptions that the designer will make. The designer must highlight to those with responsibility for procurement and to site operations teams what these assumptions are, and what should be done to verify that the design assumptions are in fact correct. Matters for the designer to consider include, but are not limited to:

- verification of foundation soils
- provision of barriers, dewatering levels and any other assumptions which affect the load case

²⁶ SCOSS Reports (available on the Structural Safety website^{xv}) are a useful source of information on safety critical features which have caused issues in the past; the database should be interrogated and like items treated with due care

²⁷ The IStructE publication, *Manual for the systematic risk assessment of high-risk structures against disproportionate collapse*, Reference^x, gives good guidance in this area; see also footnote⁹

- tests on existing fabric where incorporated into the structural system
- the early strength gain characteristics of the permanent works
- bolt types and torques
- deflections on loading
- maturity or state of the permanent works when erecting and striking the temporary works
- backpropping and second stage support

In many cases temporary works are erected, used and removed in a short space of time. However, this is not always the case and the temporary works designer should always consider the consequences if the temporary works are left in place for a prolonged period²⁸.

Where operations, maintenance or monitoring are required within the anticipated design life of the temporary works, the designer must provide clear instructions, and ensure also that appropriate safe accesses are provided. If monitoring is to be used to verify design assumptions (the 'observational technique') this is particularly important.

If maintenance or other action will become needed if the temporary works remain in place for substantially longer than the anticipated design life, this should be dealt with through the project risk management processes.

Long term effects on temporary works include wear of mechanical parts, creep, soil softening or relaxation, material degradation (especially of steels in splash zones and of timber), progressive degradation from waves, water currents, splashing and scour, exceptional weather or other intermittent actions, ratcheting effects, flooding, blocked or leaking drains and so forth.

Temporary works designers should also consider the risk of components working loose, for example vibration can cause bolts to loosen, and drying out can cause timber to shrink and work loose. There is then a loss of structural integrity, also objects might fall.

Notes on drawings are normally a sufficient means to communicate O&M (operation and maintenance) requirements. Cases which are complex, involved, use the observational technique or rely on monitoring may call for specific documents.

It can be seen from the foregoing that there are many issues which those with responsibility for procurement and construction must take on

from the designs. Their safe systems of work, to control the risks, will include risk assessments, method statements, and inspection and test plans (ITPs). All matters that they have to control (safety and otherwise) must be incorporated into these documents.

The TWC has to ensure that the project controls, as constituted within the safe system of work, address the matters raised by the design. He or she may call upon the designer or others for assistance.

In complex and high risk cases it is accepted practice for the temporary works designer to check the temporary works on site at critical stages. This role can be extended to witnessing critical verification tests.

2.3.8 Permanent works integration

In cases in which the temporary works designer considers that the interaction of the temporary and permanent works is important, or is advised of this, he or she will require confirmation from the permanent works designer that the temporary works as designed, in principle at least, suit the design requirements of the permanent works. This interaction will be managed by the project's TWC or the CDM Co-ordinator, albeit the duty placed on the CDM Co-ordinator is to take reasonable steps to ensure co-operation between designers, not to manage the interaction.

This aspect of design is particularly important if the permanent works form a part of the temporary structural system, if residual stresses or deflections in the permanent works derive from the construction method or sequence, or if the purpose of the temporary works is to stabilise the permanent works in a temporary condition. Those who commission permanent works designers should ensure they will co-operate in this aspect of temporary works design. Risk and cost will be introduced into a scheme if the permanent works designers stand back, a situation that might result from contractual or pecuniary limitation.

It may come to light, during this process, that the temporary conditions or temporary works are more complex, higher risk or of greater extent than foreseen. If this leads to a contractual position developing, various managers, and potentially the client, will need to become involved. Notwithstanding, commercial considerations must not be allowed to over-rule engineering safety or legal duty.

²⁸ For example if the permanent works scheme is abandoned part built, there is industrial action or the scheme becomes delayed

2.3.9 Quality Assurance

The temporary works designer will often work for a firm which is certificated to ISO9001 and ISO18001. Where this is the case, the temporary works designer will therefore follow the procedures which are the basis of the firm's certificate.

As a minimum standard, properly signed off drawings and other documents will be evidence of appropriate QA procedure. Where required a design certificate will be prepared.

2.4.0 Site support to be given by the temporary works designer

2.4.1 Method statements, ITPs and checklists

It is appropriate that the temporary works designer reviews the method statements, Inspection & Test Plans (ITPs) and checklists for the works designed, to confirm that requirements are met and that no sensitivities of the design are upset.

2.4.2 Change

Any change to the design requires the full rigour of the design process to be re-iterated. This will normally require, as a minimum, that elements of the calculations and drawings are re-worked and re-issued. The practice of authorising change on emails and supplementary sketches is discouraged. On occasion, change may require a full re-working of the design, all the way back to re-establishing the Design Brief.

The temporary works designer should respond as quickly as is reasonably practicable to changes which are required to the design. Notwithstanding, there must be no loss of rigour in the design process.

2.4.3 Queries

The temporary works designer will respond as quickly as is reasonably practicable to queries. Where ambiguity has to be explained, or greater clarity is needed to ensure unambiguous interpretation, the design documents will be improved, re-checked and re-issued.

2.4.4 Site attendance

The site operations team's management documents, in particular their ITP, will set down the inspections and tests for which the temporary works designer's attendance is required. In addition it is probable that the designer will need to attend meetings. In complex cases (and specifically Design Complexity Risk category DCR3 or 4, refer [Table 3](#)) it is accepted practice for the temporary works designer to check the temporary works on site at critical stages.

When these attendances are needed, the designer will strive to make them to meet the programme requirements of the contractor. Obviously, being given due notice helps.

2.4.5 Release of 'Hold Points'

Permits to Load, Permits to Continue, Permits to Strike and Permits to Demolish are common in temporary works. [Article 4](#) (below) discusses their roles in more detail.

While not compromising due process, the temporary works designer will strive to assist the contractor in all ways to release Hold Points in a timely fashion. Typical actions will include keeping to the design programme, dealing with change quickly and making site visits and inspections (where required) to meet the contractor's programme.

2.5.0 Final comment

While all temporary works designs should be design checked, the temporary works designer should work on the assumption that they will not be. In other words, the designer should assume that any error or ambiguity in his or her output will be translated into an error in the works as built and may cause structural under-performance or failure. Reliance will not be placed on a checking process as a substitute for appropriate due diligence.

²⁹ See footnote²⁰

Article 3

Good Temporary Works Design Checking

3.0.0 Introduction

A good temporary work design check is independent of the design and confirms that the design has:

- a sound basis
- a concept which is appropriate
- design documents which are clear to understand and if used properly will produce works which are safe to fabricate, erect, check once erected, use and remove

and that,

- the design as a whole is coherent and meets the brief

The last bullet point makes an important point about structural coordination. Where the temporary works design comprises more than one part and the different parts have been designed by different designers, it is the advice of this Guide that the scheme has a single, holistic check managed by a single checker who takes single-point responsibility for the check. This may involve checking structural interactions, ground conditions and the like outside the site boundary. It is advised not to check schemes in parts and rely on the TWC (temporary works coordinator) – within the checking process – to coordinate those parts for structural interaction²⁹.

For multi-part schemes, this places the temporary works design checker in a different place to temporary works designers. On such schemes the designers each focus on their own part. The checker, however, will take single-point responsibility for the holistic check, even if the checker delegates parts. In these circumstances the checker is independently checking the coordination managed by the TWC and will need to display a broader competence than the designers.

In no circumstances should a design check be limited to a numerical check of calculations; in fact it is recommended that the calculations are not given to the design checker³⁰.

It should be noted that the design check is not a peer review. Peer reviews have their place during the design process, see 2.2.0 and 2.3.6 above.

Where a client body has its own rules for temporary works design checking, the same comments are made as for temporary works

design: the client body should ensure that its rules align with best practice, and an audit against BS5975 and this document would be a useful means to do this; the rules, wherever they depart from BS5975, add to it or introduce specific requirements, should be made clear in any brief. As a matter of convenience, client body rules should strive to use common terminology and processes, as single design and contracting organisations typically work for many clients at the same time.

As with design, a good design check requires a considered appointment and briefing of the design checker. What is to be checked, on what basis, for what purpose and by when must be made clear. Competent people must be appointed and sufficient time, resources and budget allowed.

The design check will normally be commissioned by the same party as commissioned the design. For Design Complexity Risk Categories DCR3 and DCR4 (see Table 3), in which cases an independent organisation should make the check (see Table 6), the practice of inviting the designer to commission the check should be avoided: the party that commissioned the design should do it. Where the client or programme manager commissions temporary works design ahead of the construction phase, they will need to take steps to ensure the design is appropriately checked.

Where sub-contractors have provided designs, while they should get their design work checked, this Guide advises that the Principal (or Main) Contractor should undertake (or instruct) their own check. Where multiple sub-contractors have contributed parts of the overall design the Principal (or Main) Contractor should consider themselves duty-bound to undertake (or instruct) their own check, which must be holistic.

It is normal practice for the design checker to be given the full set of design documents, but it is good practice if the numerical calculations are abstracted and not given to the checker. This is the principle set out in BS5975, at Section 9.

It is prudent to ask the design checker to review the Design Brief, Design Statement and concept design before the detailed design is prepared. It is not abnormal for the temporary works designer and design checker to engage in a professional dialogue during the process. The process as a whole will be co-ordinated by the TWC.

³⁰ See BS5975 Section 9, [Reference](#)ⁱⁱ

Table 6: Checking regimes for categories of Design Complexity Risk

Category	Independence of checker
DCR00 (refer Table 3)	site procedure for authorisation of method statements applies
DCR0	another member of the site or design team
DCR1	another member of the design team
DCR2	an individual not involved in the design and not consulted by the designer
DCR3	an independent organisation not involved in the design and not consulted by the designer
DCR4	an independent organisation not involved in the design and not consulted by the designer

BS5975 sets out rules for checking according to Design Complexity. These are adopted by this Guide, with added guidance for Categories 00 and 4; see Table 6.

The remainder of this Article has the same structure as [Article 2](#). The two articles may be overlaid to see how designing and design checking complement one another.

3.1.0 Checking the Design Brief and Design Statement

The requirements of the Design Brief and Design Statement are given at 2.1.1 and 2.1.2 above. The design checker should review the Brief and Statement. The design checker should review the nature of the permanent works and the proposed construction sequence to confirm that all necessary temporary conditions of the permanent works have been identified and that the Design Brief and Design Statement sufficiently assess the loads and other criteria for the temporary works design. If unsure on any point, the design checker (through the agency of the TWC) should seek to resolve the issue with the permanent and temporary works designers. If still unsure, or dissatisfied, the design checker should reject the design and refer the matter to the TWC.

3.2.0 Checking the concept design, options studies and concept peer review

The temporary works design checker should review the documents produced by the temporary works designers, see 2.2.0. The checker will use professional judgement to assess whether or not the design has a sound concept. If unsure on any point, the design checker (through the agency of the TWC) should seek to resolve the issue with the designer. If still unsure, or dissatisfied, the design checker should reject the design and refer the matter to the TWC.

It is suggested at 2.3.6 that, where there is a peer review, the design checker could engage in it. Note that this is for the design checker to gain insight, and does not replace the design check.

3.3.0 Checking the detailed design

The requirements of the detailed design are set out at 2.3.0. The temporary works design checker should review the detailed design as set out below. If unsure on any point, the design checker (through the agency of the TWC) should seek to resolve the issue with the temporary works designer. If still unsure, or dissatisfied, the design checker should reject the design and refer the matter to the TWC.

3.3.1 Structural system

The temporary works design checker should refer only to the drawings (2.3.3) and sequence drawings (2.3.4) and derive the structural system independently. The scope of the structural system is given at 2.3.1.

3.3.2 Calculations

The temporary works design checker should not be given the design calculations; BS5975 Section 9 refers. The design checker should refer only to the drawings (2.3.3), sequence drawings (2.3.4) and the checker's own derivation of the structural system. The design checker should use professional judgement to determine a scope of check calculations which is needed to satisfy him or herself that each component and connection is sufficient at all stages of delivery, erection, use and dismantling. The scope is the entire structural system relevant to the temporary works, which may include some elements of permanent works subject to temporary loads, or in a temporary state.

Where there is a high reliance on the use of software, the design checker will be satisfied, so far as reasonably practicable, that the use of the software has not left a flaw in the design. Flaws might result from the use of the software, or be embedded in the software. The checks may require making parallel calculations using different software, or be made by other means.

3.3.3 Design drawings

The temporary works design checker should review the drawings to confirm that they correctly and fully communicate the design requirements with sufficient detail. Judgement will be based on the checker's own derivation of the structural system and check calculations. The design checker should use professional judgement to confirm that the drawings are suitable for use in a site environment.

3.3.4 Sequence drawings

The temporary works design checker should review the sequence drawings and confirm that they meet and correctly communicate the design requirements. Stability at each stage of the work will be a particular concern. Judgement will be based on the checker's own derivation of the structural system and check calculations. The design checker should use professional judgement to confirm that the drawings are suitable for use in a site environment.

3.3.5 Specification

The temporary works design checker should determine, on reviewing the drawings and preparing check calculations, what, as a minimum, needs to be included in the specification. The checker should then review the temporary works designer's specification to confirm that the matters identified have been addressed. The design checker should use professional judgement to assess that the specification is generally sufficient, clear, matches industry norms and is useable.

3.3.6 Elimination of hazards and mitigation of risk during design

The temporary works design checker should determine, on undertaking the checking work, what are considered to be the residual risks of the permanent works in temporary conditions and what are the residual risks of the temporary works design. The design checker should then use professional judgement to confirm that reasonable steps have been taken to eliminate hazards and that the residual risks are reasonable in the circumstances, and that the controls, safe accesses and so forth are sufficient.

3.3.7 Communicating risks to procurement and site operational teams

Having identified the residual risks and controls at 3.3.6, the design checker should use professional judgement to assess that both the significant risks and, where required, the controls are clearly set out in the documents, match industry norms and are practical. The controls might typically include inspections, maintenance, tests and hold points during procurement, fabrication, erection, checking once erected, use and removal.

The design checker should use professional judgement also to confirm that the designer's O&M (operation and maintenance) instructions are sufficient and are communicated with sufficient clarity. The design checker will give particular attention to temporary works reliant on mechanical, electrical or control equipment.

Temporary works which rely on the observational method, sensors or monitoring are generally restricted to geotechnical work and the stability of historic structures. There will be a degree of uncertainty. Those involved need a high level of competence, which they will have developed with considerable experience. Design checkers must have this competence and will exercise their professional judgement to decide how they assess that the design is safe, given the proposed work sequence. This topic is developed in [Appendix F](#).

3.3.8 Permanent works interaction

The design checker should review the interaction of the temporary works with the permanent works and, from an ability to understand both parts of the system, form an independent view (independent of both permanent and temporary works designers) as to the appropriateness and adequacy of the temporary works, and, where permanent works form a part of the temporary structural system, their adequacy to do so.

In the event that the design checker has concerns about the temporary/permanent works interaction, this will be taken up with the TWC. These concerns may be that, for instance,

- the permanent works are inadequate to play their part in the temporary works scheme
- the temporary works proposal will be deleterious to the permanent works
- the permanent works will be left in an unstable or unsafe condition when the temporary works are struck

The TWC will then need to manage resolution of the temporary works design checker's concerns. This may require escalation to the temporary works designer and the permanent works designer. Where there are contractual or commercial consequences, their management is a part of the escalation process and may involve various managers and potentially the client. In this process, cost and time considerations must not be allowed to over-rule engineering safety or legal duty.

3.3.9 Quality Assurance

The temporary works design checker will usually work for a firm which is certificated to ISO9001 and ISO18001. The checker will therefore follow the processes which are the basis of his or her firm's certificate. As a minimum standard, a full and clear set of the checking documents will be prepared and stored for reference, with full version and document issue control. A check certificate, or other appropriate documentation, will be prepared, which will identify the documents used to undertake the check, and those prepared as a part of the checking process.

3.4.0 Site support to be given by the temporary works design checker

The design checker will not normally be called upon to support site operations other than by responding expeditiously to change and by striving to meet information release dates to facilitate the project procurement and construction programme, in particular to allow Hold Points to be released. If asked to work quickly to avoid site delays, the design checker will nonetheless take the time needed to work diligently. Operations teams should be mindful to allow enough time for design checking.

3.5.0 Final comment

While the primary onus for accuracy lies with the designer, the design checker will consider fully the liability should an ambiguity or error remain in the design documents. Errors may cause structural under-performance or collapse. The design checker will therefore act with due diligence³¹.

³¹ Consider for instance the judgement in the Ramsgate walkway collapse of 1994, in which the design checker was found liable in significant part

Article 4

Good Temporary Works Site Inspection

4.0 Introduction

Site inspections are normally made to confirm that the works comply with specified requirements and to release Hold Points.

At Hold Points it will be formally checked that the materials and workmanship meet specification, and the works are constructed within tolerance to drawing. Any departure from these conditions represents a change to the design. Any change should be either corrected or referred (via the Temporary Works Coordinator, TWC) back to the designer and design checker for verification³². See 2.4.2.

The degree of formality of the procedure needs to be based on the degree of risk that the Hold Point is intended to control.

Hold Points occur in temporary works for a number of reasons. The most common include:

Permit to Load:

- Before the loading is applied to the temporary works (e.g. before concrete is poured)
- Before the temporary works apply load to any other structure

Permit to Continue:

- Before the next stage of works begins (e.g. before excavation continues below a frame level, before moving to a subsequent stage of a demolition sequence)

Permit to Strike:

- Before temporary works are struck (so that load is transferred from the temporary works to the permanent works).

Permit to Demolish

- Before starting a demolition sequence

It is the responsibility of the TWC to ensure that the correct Hold Points are incorporated in the Method Statement and ITP (Inspection and Test Plan) for the works. The TWC will refer to the project risk processes and register, and follow advice from the designers, design checker and site team to establish requirements. As a check, the TWC will use personal competency to check that appropriate inspections and Hold Points are identified, adding as needed to the requirements of others³³.

In planning the inspection regime, the TWC should think carefully about the issues raised in section 2.3.7, 'Communicating residual risks

to procurement and site operations teams'. This section sets out what it is likely that the procurement and site operations teams will need to take forward from the design stages in order to make the design successful in practice. The control of all these issues must be built into the procurement and site management controls. These controls will be included in the project's safe system of work and include risk assessments, method statements and ITPs.

A particular area of focus for the TWC should be any sensitivities that the design has. (See footnote⁹ on sensitivities.) Many designs have sensitivities, in the form of certain components or features which if out of specification or tolerance create a significant risk. Where these sensitivities exist, it is the responsibility of the designer to bring them to the attention of the TWC and those who will use the design. It is then for the TWC to ensure they are addressed by the project's safe system of work.

BS5975, at Sections 7.2, 7.3 and 7.4, sets out the responsibilities of the TWC and the procedure for the appointment of and responsibilities of Temporary Works Supervisors (TWS). In respect of site inspection some key points are:

- This Guide recommends that for any one part of a site for any one phase of work there is only one TWC. The TWC has single-point responsibility for all of the TWC duties, as set out in BS5975
- In the exercise of these duties, the TWC will manage the processes by which inspections are made and Permits are issued, delegating to and instructing others as appropriate
- Inspecting temporary works at critical stages is the culmination of a long and careful design development and implementation process; it is not to be undertaken lightly. In complex cases (and particularly where the design has critical sensitivities) the processes of making the inspection will benefit significantly from a knowledge of the scheme which is deeper than can be gleaned simply by reading construction drawings
- It is simplest in many ways if inspections are made by the TWC personally, provided he or she is competent to do so. If the TWC is delegating the inspection, this Guide recommends that:
 - each delegation should be limited to a single Permit or a defined group of Permits which relate to a specific process or activity

³² The 'golden rule' is that, to release the Hold Point, the temporary works as built, and the conditions around the temporary works, are (given allowable tolerances) a true match to the specification and drawings

³³ See document TW/11/27 published by the TWf regarding the necessary competence of the TWC¹

- the TWC names the inspector, who can be a member of his or her own employer's staff, or another person; the person will be someone whose competence, diligence and integrity the TWC can trust in relation to the specific inspection(s)
- notwithstanding delegation, the TWC remains responsible
- where TWSs are appointed, their scope of duties are clarified in writing; any delegated authority to sign off Permits is made explicit and not left open-ended
- the practice absolutely to be avoided is for the site to have a 'team of TWCs' any one of whom is authorised to sign off Permits; this undermines the prerogative of single-point responsibility
- to ensure independence of checks, if any of the tasks requiring checking have been carried out by the TWC, the TWC should delegate the checking to someone not so involved
- for periods of extended absence, a replacement TWC will be appointed; suitable arrangements for other absences must be planned.
- The role of TWS (Temporary Works Supervisor) is specified in BS5975. The TWS role includes site supervision and checking of the temporary works for which the TWS is specifically responsible, liaising with the TWC to ensure that any modifications to the scheme or changes of conditions from those envisaged are drawn to the attention of the relevant designers. The role may be extended to the issue of permits under the TWC's authority
- In the majority of instances, TWCs are likely to hold production and commercial responsibilities as well as their TWC responsibilities. In these circumstances, when undertaking their TWC role, they must put safety considerations first and set aside their other responsibilities, and all parties must respect this. It is likely to be only on the largest and most complex projects that an individual will undertake the TWC role as an exclusive duty. The same professional attitude is required of TWSs.

4.1 Assurance on what can be readily inspected on site, and what cannot

To know that works comply with the drawings and specification requires, in principle, two types of knowledge. The first is knowledge of what

cannot be (or is not easily) gained by physical inspection; this includes issues such as material grade or developed strength. The second is knowledge of what is straightforward to gain by physical inspection; this includes, typically, work progress, member sizes or generic type, conformance with tolerance, bolt tightness etc. The Permit cannot be signed until the TWC (or the person delegated to, to sign the Permit) is assured on both counts. The ITP should list the information, the acceptance criteria and the evidence that will be required.

4.1.1 Assurance on what cannot be readily inspected on site

The temporary works co-ordinator will use the QA processes as applied to procurement, off site manufacture, pre-testing and so forth. To gain assurance the TWC will interrogate arrangements and ensure that appropriate inspections, checks and tests are undertaken throughout the supply chain by suitably qualified and experienced people. It is unlikely that the TWC will identify QA measures over-and-above those routinely used by ISO9000 compliant organisations. However, for specific significant safety critical items³⁴ or where the designer or design checker require it, the TWC will instruct additional specific tests and inspections. These will be identified in the ITP. Where the TWC considers it appropriate, he or she will cross-check personally or instruct independent audits. The TWC will collaborate with the project QA department to ensure all records are kept correctly.

4.1.2 Assurance on what can be readily inspected on site

What can be inspected on site, in order to sign the Permit, will be inspected. It is good practice to list out what is to be inspected in a checklist. This should be prepared on a risk basis.

The inspection will be made by the TWC in person or by someone he or she delegates to. The inspections should be made by reference to the approved drawings and specification against the item being inspected. This might be in a receiving area for fabricated items, or in the field for temporary works once assembled.

In summary, site checks use two things: a pre-prepared check-list (to ensure the right things are checked) and the relevant drawings and specifications (to ensure the design details are understood by the checker at the time the check is made). In most cases, the site checker should have both types of document to hand when making the check on site.

³⁴ See footnote²⁶ re SCOSS Reports

Article 5

Good Temporary Works Co-ordination

5.1.0 Introduction

The role of the TWC (Temporary Works Co-ordinator) is set out in BS5975 and is developed in various documents, including the document 'Competencies of the TWC' which can be accessed on the TWf website (www.twforum.org.uk, document TW/11/027). The reader should refer to these documents.

The TWC is an appointment usually made by the Principal (or Main) Contractor, and the role is usually associated with the construction phase of the project. But good temporary works co-ordination starts well before that. As set out in [Table 1](#) (in the Introduction), the temporary works requirements for the project are largely fixed during the initial scheme development and permanent works design phases.

Projects will run best if the permanent works designs are developed on the principles of 'design for manufacture', which in construction might read 'designed to be built'. The CDM Co-ordinator should input to this process, and ensure that the permanent works designer does also. To achieve this, the permanent works designer should foresee methods and stages of construction and incorporate into the permanent works design all features to make this as straightforward as is reasonably practicable. As a minimum there should be an awareness of the stages of construction, identification of the temporary works required, identification of the performance criteria for the temporary works (in as far as they affect the permanent works), and a requirement for the design the permanent works to be robust to the method³⁵. Going beyond this, the permanent works should be designed in such a way that such temporary works as are required are truly necessary, and that they will be as straightforward as is practicable; the permanent works designer should also assist the construction team by adding in-built temporary works features into the permanent works drawings even if this means updating and re-issuing the permanent works drawings and schedules after the temporary works are designed.

Peer reviews of the developing permanent works design are encouraged; the SCOSS documents, References^{xiii & xiv}, set out the process. The reviews should consider construction method and temporary works. Where appropriate,

specialists in these fields should join the review panel. The Temporary Works Forum (www.twforum.org.uk) can assist with identifying suitable specialists.

During the construction phase it is good practice that critical sequences or phases of work are presented by those who will undertake them to a review panel some reasonable time before the work starts. A suitable panel will comprise senior and expert members of the client, permanent works design and Principal (or Main) Contractor organisations. This practice forces teams to plan early, to plan in detail and to be able to communicate effectively.

Good co-ordination is greatly facilitated by an ethos in which the temporary works designers hold themselves responsible, throughout the construction period, for the structural safety of all of the temporary works, and of all of the permanent works in a temporary condition; they will hold themselves responsible also for ensuring that the residual stresses and deflections of the permanent works are not deleterious. To achieve this, the temporary works designers will need to work closely with the permanent works designer and the site team.

The design checker has an important role to play in good coordination. As stated in [Article 3](#) (and at 3.3.4 specifically) the design checker for the temporary works will check the entire structural system relevant to the stability of the works at each stage of construction.

Good practice at site level normally includes what is set out below. When reviewing tenders, client's representatives and their agents should ensure that the contractors have included the personnel and costs to meet these criteria³⁶. They should then audit compliance.

Good practice at site level should include the following:

- Every contract appointing a Principal (or Main) Contractor will require explicitly that the management principles of BS5975 will be applied by the Principal (or Main) Contractor, and extended throughout the supply chain
- There is only one TWC responsible for any specific site or, in specific circumstances, area of the site, and it is clear who that person is: there is single-point responsibility; arrangements to cover TWC absences are equally clear

³⁵ Indeed, to fail to do this is likely to fall short of the designer's duties under the CDM Regs

³⁶ One very senior programme manager was overheard to say that, had he appreciated these points when setting up his recent projects, he would have paid rather more attention to the Principal Contractor's proposed TWC than to his proposed Project Manager, the TWC role being clearly the more significant for a successful outcome

- There is no area of the site which does not have a TWC, even if at first sight there appears to be no temporary works associated with that area³⁷
- The role and duties of TWSs (Temporary Works Supervisors), as set out in BS5975, are properly detailed and understood. The TWC will co-ordinate the activity of all TWSs on the project (in as far as their work is to do with temporary works) irrespective of employer, contract or commercial boundary. Contracts must be set up to allow this
- The TWC is formally appointed in writing by the Designated Individual (BS5975 refers) of the Principal (or Main) Contractor. The TWC may have temporary works co-ordination duties as sole priority. However, on all but the most major projects, the TWC will normally have production responsibilities and must therefore be able to work with independence of mind when undertaking TWC duties (BS5975 Clause 7.2.3 refers)
- The TWC appointment gives the TWC an adequate level of authority, which includes the authority to stop the job for safety reasons
- All TWSs are appointed in writing, and their duty to work with the TWC is made clear in their appointment
- The TWC must be competent at least to the level of being able to identify the issues with the temporary works that must be resolved³⁸. An ability to design is normally an advantage, but is not a pre-requisite³⁹. However, the TWC will never use this ability to authorise even minor designs or design changes, because that would usurp the formal roles of the appointed designer and design checker. All changes should be referred back to the designer and design checker
- Where the client or other party designs all or part of the temporary works, or part of the permanent works whose structural performance influences the temporary works, the TWC is given full access to this designer's work and is given access to the CDM-C to seek resolution where issues of structural safety are found
- The TWC will ensure that all elements of temporary works within his or her area of the works are identified and put on a Temporary Works Register (BS5975 refers). The Temporary Works Register will record that all the items of temporary works have a sufficient design basis, detailed design and design check, and that there is a satisfactory match between the design intent (drawings and specification) and the works themselves
- All design documents will be fully checked and properly issued for construction in accordance with accredited QA procedure
- The TWC will ensure that the project ITPs and Method Statements include the Hold Points and other controls required by the designer, and such other Hold Points and controls as are needed, to ensure safety and structural performance; the TWC will know personally that all aspects of the ITPs have been fulfilled in as far as they affect the temporary works
- The point made in [Article 4](#), that inspecting temporary works at critical stages is the culmination of a long and careful design development and implementation process, will be fully recognised as critical to the process of effective temporary works co-ordination

³⁷ *Doubters please read [Appendix B](#)*

³⁸ *See [Appendix A](#) penultimate paragraph*

³⁹ *The value of the TWC being able to design will manifest itself in his or her ability to*

- *Identify all requirements for temporary works and the principal performance requirements'*
- *Identify everything that constitutes temporary works*
- *Set up and scrutinise design briefs*
- *Correctly identify Hold Points*
- *Write check-lists for inspections*
- *Ensure that checks and tests used during procurement, fabrication and site acceptance meet design safety needs*
- *Personally cross-check the competence of others*
- *Identify when suppliers and sub-contractors design is incomplete*
- *Identify what co-ordination is needed between designers of different parts of the structural system, and be able to assure, by delegation to a design checker or personally, that this has been done adequately*
- *Run supplementary checks on designs*

- The TWC will recognise that a purpose of the role is to ensure that the temporary works (and the permanent works in temporary conditions) are safe and fit for purpose, and that all constraints on their use are understood. The TWC will understand that this derives from good concepts, thorough understanding, close attention to detail and good communication. The TWC's colleagues and managers will recognise the onus of this duty and will support the TWC to discharge it. Notwithstanding, the TWC will see to it that the temporary works are economic within these overall constraints
- Everyone in the team knows and understands their role with respect to temporary works.

For example, a commercial manager letting a sub-contract will know how the pricing of the package adds to or detracts from temporary works safety. All personnel will understand the importance of good information, adequate time, adequate supervision and proper competence; commercial arrangements will support these requirements

- Throughout the team it will be recognised that gravity never takes a day off, and that nature will search out any deficiency of design or construction. There is no place for taking chances or hoping for the best. All those involved must know for sure that the design and construction are adequate

Appendix A

Assessing competence

The assessment of competence is central to safety management and is a broad subject. Its detail is beyond the scope of this document. However, it is generally accepted that competence is built on relevant qualifications, experience and qualities appropriate to duties.

The Health & Safety Executive is able to assist and has published guidance. See for instance 'Managing competence for safety-related systems'^{xvi}. Their documentation should be referred to.

The authors are unaware of any formal requirement for client competence in the area of temporary works. However, as competence is an implied prerequisite for meaningful action in the discharge of duties under the CDM Regulations, it seems reasonable to assume that for clients to discharge their identified duties, they must have a level of competence.

In the domain of tunnelling, this theme has been taken up by the British Tunnelling Society and developed by The International Tunnelling Insurance Group (ITIG). Their document 'A Code of Practice for Risk Management of Tunnel Works' (2nd Edition 2012)^{xvii} gives guidance (at Section 5) for the assessment of client competence, proposes that clients self-assess against a set of criteria and recommends that clients who find shortfalls in their own competence appoint representatives appropriately. [Table A1](#) below sets out the ITIG recommendations and suggests how these might be adapted to temporary works. This Guide proposes that these criteria can be used in any circumstances in which a body or party is acting in the role of a client: they need not be The Client for the scheme; for instance they might be:

- a Project Manager assessing the competence of a Principal or Main Contractor
- the Commercial Manager of a Principal or Main Contractor procuring a sub-contract in which temporary works occur
- a contractor procuring specialist design

The point is that procurement in the area of temporary works is an expert business requiring competence; it is not akin to buying goods in a supermarket^{40, xviii}.

A means to assess, or self-assess, would be to gauge familiarity with the concepts that underlie this document. If they are new or seem obscure or irrelevant, that is not a good sign. (Whether or not the reader agrees with them is another point.)

The execution of site works is an example of a complex and highly interactive operational environment given detailed treatment by Weick and Sutcliffe in their seminal work 'Managing The Unexpected'^{viii}. In these operational circumstances they identify the need for High Performing Organisations. These embrace the concept of mindfulness, which is founded on

- preoccupation with failure
- reluctance to simplify
- sensitivity to operations
- commitment to resilience
- deference to expertise

Weick and Sutcliffe conclude that those organisations which embrace mindfulness have fewer than their fair share of accidents, given their operating environment. These principles have been adopted by the chemical, petrochem and process industries and could usefully be adopted across civil, building and construction engineering. High levels of competence are a prerequisite.

The Temporary Works Forum has published a document addressing the competence of the TWC (Temporary Works Coordinator), document TW/11/027 at www.twforum.org.uk. See also section 5.1.0 of the main text of this Guide, and footnote³⁹ in particular, concerning the ability of the TWC to design, which brings supplementary benefits.

In the area of competence in temporary works, the TWf will be able to advise, or to recommend advisors or expert assessors, and can also recommend suitable agents or representatives who would be able to fill any gaps in teams. Please contact the Secretary.

⁴⁰ This theme is developed in work by Naim and Gosling. See for instance [reference](#)^{xviii}

Table A1: Client Role And Responsibilities As Given in the ITIG Guide^{xvii} Adapted for Temporary Works

Extract from the ITIG Code ^{xvii}	Possible Adaptation for Temporary Works
<p>5.1 The Client shall have demonstrable technical and contract management competence appropriate to the type, scope and extent of the project to be planned, designed and procured for construction in:</p> <ul style="list-style-type: none"> a) Project Development Stage studies b) Design Stages c) Construction Contract Procurement Stage procedures including selection of a Form of Contract d) Construction Stage and management 	<p>No change</p>
<p>5.2 Such competence shall be demonstrable and evaluated on the basis of:</p> <ul style="list-style-type: none"> a) The Corporate Competence of the Client body in relation to the proposed project and/or b) The competence of individual staff within the Client body including their availability for the project 	<p>No change</p>
<p>5.3 In the absence of appropriate experience for any part of the project, the Client shall appoint a Client's Representative. The appointment of the Client's Representative should be based on a structured selection exercise. The criteria for the selection and the appointment of a Client's Representative should be similar to those with which the Client assesses his own capability at the outset and include consideration of the following:</p> <ul style="list-style-type: none"> a) The corporate competence of the company including references from previous clients (which should be followed up) b) The competence of staff c) Named key personnel d) An assessment of the project planning competence including the planning, procurement, execution and interpretation of site and ground investigations e) Design capability including competence in the type of Tunnel Works to be designed and associated construction techniques f) Capability in respect of the management (or procurement in the case of design-construct arrangements) of design, Design Checking and review procedures and the preparation of appropriate design related Risk Assessment and Risk Registers g) Capability in respect of the identification and management during the Design Stage of health and safety design-related matters including those relating directly to operatives and all other persons directly engaged on the Tunnel Works as well as such matters arising from design arrangement(s) that will impact on Third Parties and the preparation of appropriate Risk Assessments and Risk Registers h) Presentation by Key Personnel proposed for the project and confirmation of their availability i) Financial stability of the company/organisation 	<p>No change in opening paragraph</p> <ul style="list-style-type: none"> a) No change b) No change c) No change d) No change but add ' , design services, construction methods and determination of temporary works' e) Change 'type of Tunnel Works' to 'type of construction', and add at end 'and temporary works' f) No change g) No change h) No change i) No change
<p>5.4 The Client shall take full responsibility for the information prepared by him (or by his Client's Representative) and issued to tenderers as 'works information'</p>	<p>No change</p>
<p>5.5 The Client shall ensure that provision is made for the appointment(s) of an identified individual or individuals who is/are suitably qualified and experienced and hence competent in risk management practices and responsible for the identification, collection, collation and coordination of hazards and associated risks and the development and preparation of appropriate Risk Assessment and Risk Registers for each and all stages of a Tunnel Works consistent with the requirements of this Code</p>	<p>Change (towards the end) 'a Tunnel Works' to 'construction' and 'this Code' to 'this Guide'</p>

Table A1: Client Role And Responsibilities As Given in the ITIG Guide^{xvii} Adapted for Temporary Works – continued

Extract from the ITIG Code ^{xvii}	Possible Adaptation for Temporary Works
<p>5.6 The Client shall identify and make available arrangements for checking of designs, construction supervision and monitoring of Tunnel Works</p>	<p>Change to 'The Client shall see that proper arrangements are made for checking of designs, construction supervision and control of the temporary conditions and temporary works, consistent with the requirements of this Guide'</p>
<p>5.7 The Client shall develop and maintain during the course of the Tunnel Works^a (or have developed and maintained on his behalf) an Overall Management Organisation Chart which should identify reporting structures and lines of communication between the Client (or Client's Representative), the Designer(s) and the Contractor including supervision and monitoring of the Tunnel Works^b. The Chart should be accompanied with the curricula vitae of key personnel from these organisations to support and demonstrate the competence of those persons designated for the design, construction and project management of the works</p>	<p>Generally no change, except at superscript (a) and (b): ^a change 'Tunnel Works' to 'construction' ^b change 'Tunnel Works' to 'temporary works'</p>
<p>5.8 The Client shall take into account all other matters relating to his role and responsibilities referred to in subsequent sections of this Code</p>	<p>Change 'in subsequent sections of this Code' to 'in legislation and in this Guide'</p>

Appendix B

What are 'temporary works'?

A classical definition is that temporary works are temporary structures which are needed to give stability or support to the permanent structure during construction until the permanent structure can support itself. Falsework and formwork for concrete and arch centering are thus classically 'temporary works'. The same idea extends naturally to facade retention, needling, propping and other such structures which give support in temporary conditions.

The boundaries have been extended over the years to capture a range of structural components and effects that are temporary in their nature. The most obvious of these are structures which are temporary and are needed to construct the works but do not support the permanent works. These include hoardings, excavation support, cofferdams and the foundations and support platforms for heavy plant. Some of these structures are built of steel, concrete and timber; others are geotechnical. These principles routinely extend to plant used in any non-standard way, and to battered excavations. Few today would dispute that these things are 'temporary works'.

Consensus begins to wane when we move on to temporary stresses within, and temporary stability states of, the permanent works, and even more so when it comes to stresses locked into the permanent works as a consequence of the construction method or sequence. Also, what about parts of the permanent works that are used for temporary purposes? Steel/concrete composite structures often use the permanent steel as a part of the falsework, for instance, or a floor slab might be used as a working platform or to backprop floors above. Some parts of the permanent works may be modified specifically to meet temporary works cases. For example in deep basement construction, sometimes the edge bay of the below-ground slabs is designed to be cast early to provide a deep perimeter waling beam. An area that has caused many incidents over the years is the inherent instability (through lack of torsional rigidity) of bridge beams when they are first handled and placed, before the deck is cast. Another area with a catalogue of failures is underpinning, the problem here being that the 'pins' are used as retaining walls, the most critical case being the one when the excavation is fully dug just before the base slab (which acts as a strut) is cast.

Another area where opinions differ is around loads and stresses within 'plant'. Few would consider that a crane used in normal duties is 'temporary works'. However, most would consider that a lifting gantry specific to the project is. What about lifting equipment, or its attachment points on, say, a precast concrete beam? The guiding principle seems to be that where plant is structurally self-contained and is used entirely within the parameters contemplated by its designer and commissioning test regime, then it does not need to be considered to be

'temporary works'. However, as soon as there are structural or stability interdependencies, or reliance on some project-specific feature, or the application becomes non-standard, the plant item does become 'temporary works' and must be subject to the full rigour of temporary works management procedures⁴¹. To this end, plant support 'mats' of rolled stone, the stability of a barge-mounted crane and the overall performance of a sheet-piled excavation are all 'temporary works', notwithstanding that the crane, the barge and the sheet-piles might all be being used in standard ways.

Temporary structures which serve 'permanent works' functions are also a grey area, for example temporary stadia or banks of seating. Used on a construction site such structures will be treated as 'temporary works' and managed accordingly. Used not on a construction site, they will be treated in a different way and this may explain the high incidence of failures^{42, xix}.

Another troublesome area concerns interim layouts of the permanent works. Is the interim layout of, say, a station concourse 'temporary works' or not? Crowd safety in the temporary condition is very much an issue. If not 'temporary works', how should it be managed? What about over-pumping schemes for water or drainage schemes, or temporary configurations of process plant?

A further area of difficulty for the industry is temporary mechanical and electrical installations. For instance, temporary lighting or ventilation schemes are not regarded as 'temporary works' in the conventional sense.

It is noteworthy that Grant and Pallett (ICE Publishing 2012^{xx}) cover 25 types of temporary works in the chapters of their book; see [Appendix C](#).

A safe position is to consider that every condition on site is temporary works unless proven otherwise. The two main exceptions being

- a. Completed permanent work which is subjected to loads no greater than, and in no way different from, those for which the permanent works designer designed it
- b. Plant which is self-contained and used for the duties for which it is certified

It can be seen that there is some skill and expertise needed simply to identify and categorise the temporary works correctly on a project. The significance of the interactions of the permanent works, temporary works and construction method are also clear to see.

Whether or not something is strictly 'temporary works' or not does not alter the fact that it must be managed safely. The management system set out in BS5975 is well proven and its principles can be applied wherever design and construction are interwoven. Those with responsibility must ensure that professionals with the necessary competence are appointed, who also wish, and are paid, to collaborate. This applies equally to the permanent and temporary works teams. It is good practice to design structures to be built, they cannot be wished into place.

⁴¹ *The procedures are set out in BS5975ⁱⁱ*

⁴² *The Institution of Structural Engineers has published guidance in this area, see [Reference^{xix}](#)*

Appendix C

Examples and categories of temporary works

Most practitioners quite rightly give different attention to different risk categories of temporary works. BS5975 uses Categories 0, 1, 2 and 3. BS5975, Table 1, describes the Categories and gives advice on design and checking procedure. This Guide adopts the BS5975 Categories in the context of Design Complexity Risk and adds two additional Categories to the scale: Design Complexity Risk Category DCR00 and Category DCR4. [Article 1](#) of this Guide refers. Alongside Design Complexity Risk,

this Guide introduces Consequence of Failure Risk and Execution Risk.

Some examples, drawn from common industry practice, of the categories of Design Complexity Risk are given in the Table C1. These examples assume Consequence of Failure Risk and Execution Risk are normal for the type of work (no uplift to DCR is applied as a result of high CFR or ER, Tables 2, 3 & 4 in [Article 1](#) refer).

The headings of the chapters of Grant and Pallett^{xx} give a useful view over types of temporary works. The chapter headings are listed below Table C1.

Table C1: Examples of temporary works by category of Design Complexity Risk

Category of Design Complexity Risk	Scope from Table 1 of BS5975:2008+A1:2011	Examples from industry practice
DCR00 (refer Table 3)	N/a	Kicker shutters, local and small scale shaping of the ground, small, single lift short duration access scaffolds controlled by 'Scafftag' or similar
DCR0	Restricted to standard solutions only, to ensure the site conditions do not conflict with the scope or limitations of the chosen standard solution	Shallow trenches, pits and excavated batters, not exceeding 1.2m depth with no significant overburden or groundwater Low-rise formwork at ground/excavation level, max 2.4m double sided, 0.9m single sided Non-design scaffolds to TG20:13 ^{xxi} tables Site hoarding and fencing less than 2m high Other low risk items generally less than 1.2m high or 1.2m deep
DCR1	For simple designs. These may include: formwork; falsework (where top restraint is not assumed); needling and propping to brickwork openings in single storey construction	Use of standard components to catalogue design Pits and trenches to CIRIA 97 Trenching Practice ^{xxii} Excavated slopes not exceeding 30deg incline or 2m height in free draining soil Designed scaffolds and loading platforms to TG20:13 ^{xxi} tables Double sided formwork with access platforms at ground/excavation level Single sided formwork to 2.4m Routine formworks/falseworks at not more than 6m height, slabs not exceeding 500mm thick, beams not exceeding 1m width, 1.5m depth Mobile crane outrigger foundations in good ground crane to 50T Piling gates, simple and medium designs Permanent falsework e.g. metal decking Site hoarding and fencing greater than 2m high Concrete pumps outriggers with good access /good ground conditions

Table C1: Examples of temporary works by category of Design Complexity Risk – continued

Category of Design Complexity Risk	Scope from Table 1 of BS5975:2008+A1:2011	Examples from industry practice
DCR2	On more complex or involved designs. Designs for excavations, for foundations for structural steelwork connections, for reinforced concrete	Departures from catalogue design for standard components Formwork and falsework at height greater 6m or for heavy suspended slabs and beams Falseworks requiring the use of bridging and similar heavy equipment Inclined formwork Special designed scaffolds Large, complex or unusual system formwork or falsework Cofferdams and sheet piled walls, contiguous piled temporary walls Excavation frames Underpinning sequences (routine) Slope stability and battered excavation; surcharging weak ground Demolition methods and temporary conditions - generally Piling and craneage platforms; outrigger foundations in good ground crane exceeds 50T Designed lifting equipment; Piling gates of unusual or complex design Barge mounted equipment Tower crane bases unless of complex design Facade retention schemes Routine stress cases in the permanent works resulting from temporary conditions Early striking calculations Conventional tower crane bases Backpropping designs
DCR3	For complex or innovative designs, which result in complex sequences of moving and/or construction of either the temporary works or the permanent works	Temporary works combining inter-acting multiple designs Unusual concepts Bridge erection schemes and bridge temporary bracing Bridge demolition Structurally complex partial demolition or modification of existing structures Excavations and cofferdams in tidal conditions Excavations and cofferdams in poor ground (fill to deeper than 5m, water bearing fills) Large basement excavation and propping schemes Underpinning in poor soils, with surcharge and/or where the 'pins' act as retaining walls Pile and crane mats on poor ground (soft clays, water bearing soils, loose materials) Complex or suspended tower crane bases Components used as part of a crane or other mechanical equipment Hydraulic pressure pipework testing Pneumatic pressure pipework testing Abnormal stress cases in the permanent works resulting from temporary conditions Any scheme reliant on the 'observational method' or sensors and monitoring Assessment of structures likely to be affected by settlement or vibration caused by the method of work

Table C1: Examples of temporary works by category of Design Complexity Risk – continued

Category of Design Complexity Risk	Scope from Table 1 of BS5975:2008+A1:2011	Examples from industry practice
DCR4	N/a	Abnormal and highly innovative designs beyond the scope of normal design codes and practice Use of glass as a structural material Long span bridge erection Work on sensitive clays Providing vertical support using an aero engine

Chapters 3 - 27 of Grant and Pallett (ICE Publishing 2012)^{xx}

Site compounds and set-up; tower cranes bases; site roads and working platforms; control of groundwater; lime and cement stabilisation; jet grouting; artificial ground freezing; slope stability in temporary excavations; sheet piling; trenching; diaphragm walls; contiguous and secant

piled walls; caissons and shafts; bearing piles; jetties and plant platforms; floating plant; temporary bridging; heavy moves; access and proprietary scaffolds; falsework; formwork; soffit formwork; climbing and slip forms; temporary facade retention; bridge installation techniques.

(Note: the first two chapters are: Safety, statutory and contractual obligations; management of temporary works)

Appendix D

Essential differences between temporary works and permanent works

Table D1 gives a number of ways in which temporary works are often somewhat different from permanent works. These can be traps for the unwary and support the experience of the industry that temporary works differ essentially from permanent works, and that even the best permanent works designers will need to re-train to an extent to make the transition to become a temporary works designer.

Table D1: Essential differences between temporary works and permanent works

	Typical Scenarios	
	Permanent Works	Temporary Works
In-serviceability stress levels	Low	High
Limit state	Usually ultimate	Usually serviceability (deflection driven)
Predominant codes	Limit state	The industry is in a state of transition, with both permissible stress & limit state codes in use
Robustness	High	Low
Ratio live/dead load	Typically 50/50	Typically 10/1 with extreme patterns
Duration of use	60 -120 years	Days, weeks or months (but can become years and be left unmonitored if a scheme is delayed or abandoned)
Supervision under maximum load	Nil	Usually supervised by construction team
Structural interdependency	Stand alone, invariant surroundings except identified risk events	Often braced or supported by other structures which are in a state of flux
Component types	Bespoke to project, always new	Suppliers' systems, often second hand, grouped, eccentric connections
Legacy and warranty	Long term	Gone on work completion (with the exception of deleterious residual stresses or strains if any)
Planning	Widely negotiated, can take years	Quick, under site pressure
Published work, training, teaching and research	£billion industry	£million industry
Reliance on others to design the construction method	High (notwithstanding the legislation)	Usually none

Appendix E

Knowledge sources and innovation in temporary works

The main references on temporary works are

- BS 5975 (currently at revision BS5975:2008 + A1:2011): 'Code of practice for temporary works procedures and the permissible stress design of falsework'ⁱⁱ
- The book 'Temporary Works: Principles of Design and Construction' by Grant and Pallett (ICE Publishing 2012)^{xx}
- The book 'Formwork: A Guide To Good Practice (3rd Edition, The Concrete Society 2011)'^{xxiii}
- BS8167:2011: Code of Practice for Full and Partial Demolition^{xxiv}
- The Temporary Works Forum (TWf) website www.twforum.org.ukⁱ

The other documents given in References, while of a more general nature, should also be studied. The TWf website gives a further reading list.

The Structural Eurocodes make little attempt to address temporary works specifically, and their application to temporary works is considered by some to be impractical. See section 1.2.2 in the main text.

It is noteworthy that there is very little formal research in the discipline of temporary works and very little reference in university engineering degrees or post-graduate courses.

The majority of the expertise in temporary works engineering in the UK lies within technical groupings, which are found in well-established client bodies, Principal Contractors' engineering teams, specialist suppliers' design teams (in particular suppliers of plant and equipment, excavation and demolition specialists and structural frame construction companies) and a range of small, specialist consultants. With exceptions it is not the case that expertise is found amongst the major structural design consultancies. The exceptions are individual people or teams. This probably stems from the separation of the contractual responsibility for permanent works and temporary works design and lack of involvement of many permanent works designers in construction issues.

Innovation in the industry is mainly driven by equipment suppliers, the majority of whom are based outside the UK. The Eurocodes, which offer ways to design more economically if a range of characteristic factors are known rather than assumed, may drive a new wave of equipment testing. It is noteworthy that the Bragg Report of 1975 recommended a range of testing and that centres of excellence be established. In reality this has not been done; rather those centres such as the BRE, BCSA and C&CA which have supported research in the subject have lost funding or closed. Client bodies may be able to assist by supporting the practice of using their projects as 'living laboratories' to monitor stresses and undertake field studies and other activities (which are safe) on their projects. The Temporary Works Forum has a live list of research topics and would gladly suggest what should be looked at and how. The Temporary Works Forum is striving to form a research and academic teaching centre in UK, but this may take some time to come about.

Appendix F

Special considerations for design checking where the 'observational method' is used, or there is reliance on sensors & monitoring

Temporary works which rely on the observational method and/or sensors and monitoring are generally restricted to geotechnical work and the stability of historic structures. There will be a degree of uncertainty. Those involved need a high level of competence, which they will have developed with considerable experience. Design checkers must have this competence and will exercise their professional judgement to decide how they assess that the design is safe, given the proposed work sequence.

In simple situations, for example a building basement in level ground, in well understood soils and above the water table, the temporary works design checker may consider it sufficient to be satisfied that the proposed monitoring and control regime addresses the critical issues.

In complex cases, for example a deep civil engineering structure such as a station box for an underground railway, greater rigour is needed and it would be appropriate for the design checker to fully develop the monitoring regime and criteria for management independently of the designer, before viewing the proposals from the designer. In these circumstances,

once the design checker's regime is designed and set down as a matter of record, the design checker will review the designer's proposal. The design checker will then use professional judgement to assess whether the designer's proposal is in fact adequate despite differences. The design checker will then write down as a matter of record that he or she has accepted the designer's proposal. It is likely that some interaction between the designer and design checker will be needed. In summary, for complex cases:

- a. Designer proposes
- b. Design checker produces independent proposals
- c. Design checker and designer negotiate
- d. Both parties content
- e. (a) – (d) above fully documented.

In these circumstances it is essential that the client is fully apprised of the risks associated with such an approach. The level of potential for failure is well documented (for example in relation to the Heathrow failure in 1994^{xxv}, or contact SCOSS at www.structural-safety.org). However great success is also achievable, for example the Jubilee Line Extension station box at Westminster, also dating from the 1990's^{xxvi}, or contact the British Tunnelling Society at www.britishtunnelling.org.uk

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