Temporary Works Toolkit

Part 7: Temporary works failures – what can we learn?

The Temporary Works Toolkit is a series of articles aimed primarily at assisting the permanent works designer with temporary works issues. Buildability – sometimes referred to now as 'construction method engineering' – is not a new concept and one always recognised as vital to the realisation of one's ideas; it ought to be at the forefront of an engineer's mind.

www.twforum.org.uk

Temporary Works forum
Promoting best practice in the construction industry.

In the second of two articles examining temporary works failures, Director of Structural-Safety, Alastair Soane, considers why failures occur and what steps can be taken to reduce the risk of catastrophic events.

In Part 5 of this series[1], we briefly discussed the common causes of temporary works failures, illustrating the risks with a series of examples. In this article, we look in more detail at the possible reasons for failure and consider what lessons can be learned.

Reasons for failure

Reasons for failure can start at the beginning of a project with a lack of research into prevailing conditions, such as having an inadequate ground investigation or no appreciation of possible environmental effects. Flooding, high wind, fire, unusual heat or cold, and other extreme circumstances may have to be considered at the earliest stages. At concept stage, the possible risks have to be identified and assessed, with steps taken to either eliminate them or reduce their impact.

Assessment of loads forms an important aspect of starting design development; with temporary works the ratios of imposed load to dead load are particularly important. Imposed loads are often applied to their full values after the installation of temporary works, unlike the live loads on many permanent structures, which may only be rarely applied.

Codes of practice for design are written with permanent structures in mind, although there are some clauses permitting lower factors for limited lifespans. Designs, general arrangement drawings and fabrication or other specialist drawings all have to be produced with the same care for temporary works as for permanent structures.

The design checking requirements for the different classes, depending upon importance and complexity, are given in Table 1 of BS 5975[2]:

- **Class 0 –** temporary works designs may be checked by another member of the site or design team. Standard solutions often come with manufacturer-calculated working or ultimate capacities, but still need to be checked for compliance with the design criteria to ensure they will be fit for purpose.
- **Class 1 –** temporary works designs can be checked by another member of the design team.
- **Class 2 –** temporary works designs must be checked by someone independent from the design team (not involved in or consulted by the original design team).
- **Class 3 –** temporary works designs must be checked by a third-party organisation independent from the design team organisation.

In all cases, the design check should consider: the design concept, strength and structural adequacy (including lateral stability and overturning), and compliance with the design brief. These are the minimum requirements and may need to be enhanced to consider the risks that may be present. A lack of proper design or a deficiency in the checking regime can lead to failure.

There may be differences in the approvals process depending on the regulations in a particular country. In the UK, this will not have to be undertaken for Building Regulations approval, but in Germany, for example, the Proof Engineer must approve all stages of construction, including temporary works.

The design/construction interface is a frequent source of problems and the root cause of many failures is lack of clarity on design constraints to those who build, aggravated by poor communication. Well-intentioned decisions taken on site can compromise design intent and the safety of the works. Designers should be better at identifying critical constraints, especially in higher risk situations, and contractors should further mitigate the risk of misunderstanding by actively seeking confirmation that their chosen method of construction does not compromise the design. Parties to a project have to be sure how that finished state will be arrived at safely and consider the implications of any proposed construction methodology on safety at all intermediate stages.

Put more formally, in the UK it is a

statutory requirement for pre-construction information, which should contain details of significant residual risks, to be passed via the principal designer to the contractor. Even though the parties may be from the same organisation, this should be done through nominated individuals who have authority for design and construction issues.

Of course, when temporary works are involved, then a temporary works coordinator should be engaged in the process: firstly, to give advice as to the practicality of the design proposals; and secondly, when on site, to ensure control as envisaged by BS 5975.

There should be a method statement for the works which has been agreed with the designer and communicated to those actually carrying out the work. The method statement is not there as a paper trail for protection; it is there to be implemented.

In safety-critical situations it is important that the risk management process is controlled by someone who is capable and experienced. This process should include 'lessons from past experiences'. There may also be occasions, in high-risk situations, where an independent reviewer should be engaged to provide oversight (as recommended by SCOSS for structures[3]).

Projects, temporary or permanent, require an intimate relationship between design and construction. It is prudent for the design team to visit the site during the works when possible and liaise with the site staff to assure safety is being achieved. CROSS data indicate that about 50% of failures occur during the construction phase, with 25% during design, and the remainder occurring during the service life of the structure.

What can be learned?

As the case studies in Part 5 of this series demonstrate[1], the consequences of failure can be very severe and include:

- damage
- delay
- high costs
- loss of income
- loss of reputation
- loss of life and injuries
- criminal and civil liabilities.

A major component in the development of site safety in the UK was the publication of the 1976 Bragg Report[4]. Progress since then was examined in the paper 'Re-visiting Bragg to keep UK's temporary works safe under EuroNorms'[5]. To quote from this paper:

'About 40 years ago the UK construction industry was enjoying a heyday. Motorway construction in particular was in full swing. It was a period also of considerable physical danger. In the 1960s and early 1970s the falsework for a number of bridges collapsed during construction and the government was moved to determine whether the industry was in a fit state to manage falsework. Professor Stephen Bragg was commissioned to investigate, and his final report helped to set the standard for temporary works design and management in the UK.

'The nub of the report lies in the 27 principal recommendations, which cover design, site management, regulation, research, published data, testing, training and education, certification of operatives, client role and the need for authoritative publications. The most celebrated are no. 17, which is the need to appoint a temporary works coordinator (TWC), and no. 3, which requires the designer to consider a horizontal load of 1% of vertical plus calculated horizontal loads or 3% of vertical, whichever is greater (BS 5975 uses 2.5% in place of 3%).'

The themes of coordinated safety management and the importance of lateral stability were identified by Bragg as far back as the 1970s, yet many of the failures that are now seen demonstrate the same failings, so lessons have not been learned universally.

A valuable contribution to safety was a Health and Safety Executive (HSE) report[6] published in 2011 which asked the questions: what are catastrophic events in construction and what can be done to seek to prevent them? The project examined these 'low-probability, but high-consequence' safety hazards by looking at:

- the types of catastrophic event which have occurred or which might occur during construction
- the reasons for occurrence when there have been (or could have been) catastrophic events during construction, including an examination of the underlying factors
- the controls which should contribute to an avoidance of a catastrophic event
- where the UK construction industry could improve.

Examples of occurrences which may be catastrophic events are: structural collapse of a permanent structure; collapse of temporary works; collapse of plant or equipment, such as cranes; fire; tunnel collapse; and disruption of underground services. Typically, these will involve the uncontrolled release of large amounts of stored energy and, as such, will – once they start – be very difficult (or impossible) to control.

Catastrophic events would also be those having the potential for multiple deaths and serious injuries in a single incident and/or serious disruption of infrastructure (e.g. road, rail) and/or services (e.g. power, telecoms). The potential impact of a catastrophic event upon a company means that directors and senior managers need to consider the risks they are exposed to and manage accordingly.

While not as technically detailed as the Bragg Report, the HSE report emphasises the range and magnitude of problems that can be encountered in cases of severe collapse with potentially high risks to the public, workers and infrastructure.

In Part 2 of this series[7], John Carpenter aimed to assist permanent works designers in their legal obligations in relation to temporary works, stemming from the UK Construction (Design and Management) Regulations 2015 (CDM 2015), and also to demonstrate the wider project benefits of careful consideration. The advice was also designed to be of use to principal designers (a legally required client appointment on most projects under CDM 2015), and to clients concerning what should be expected of permanent works designers on their projects.

"IN SAFETY-CRITICAL SITUATIONS IT IS IMPORTANT THAT THE RISK MANAGEMENT PROCESS IS CONTROLLED BY SOMEONE WHO IS CAPABLE AND EXPERIENCED"

The factors that cause, or contribute to, temporary works failures are in the main well known and are containable. Mostly, of course, such works are carried out safely and securely with the application of considerable skill and competency. It is the small proportion that go wrong which must be prevented, but how?

Conclusions

Education is a vital factor in passing on the lessons of the past. Engineering teaching does not usually dwell on temporary works, but a thorough grounding in sound principles pays dividends whether applied to permanent or temporary works. Similarly, risk recognition and risk analysis are not mainstream subjects and there should be more course content aimed at emphasising the serious risks that can be faced. In some cases, feedback from failures results in changes in legislation or regulation so that designers and constructors are forced in certain directions. This, however, can take many years and regulations usually set only minimum standards.

A very effective mechanism for preventing failure is to learn from previous experiences. For 40 years, SCOSS and, more recently, CROSS, combined at Structural-Safety[8], have been active in providing guidance on structural safety in the UK. They examine incidences of failure or collapse, wherever they occurred, and consider whether there are lessons that can be learned and passed on to industry with comments that can help prevent similar occurrences. Their publications are widely distributed and read, both on site and in design offices, by engineers who then apply the lessons to their projects.

To bring about a reduction in failures, there needs to be concentrated attention by governments, national and local, on initiating, legislating on, and enforcing measures to improve construction standards.

Alastair Soane BSc, CEng, PhD, FICE, FIStructE is Director of Structural-Safety. He is a member of the Ethics Committee of the Royal Academy of Engineering, the Advisory Group on Temporary Structures and other Institution of Structural Engineers committees. Alastair is also Visiting Professor at Liverpool University.

REFERENCES

►1) Soane A. (2017) 'Temporary Works Toolkit. Part 5: Temporary works failures – what are the common causes?', *The Structural Engineer*, 95 (1), pp. 24–26

►2) British Standards Institution (2008) *BS 5975:2008+A1:2011 Code of practice for temporary works procedures and the permissible stress design of falsework*, London: BSI

►3) SCOSS (2009) *Topic paper SC/09/035: Appointment of independent reviewer through peer assist* [Online] Available at: www.structural-safety.org/media/24156/120_SC09.035__WEB_IR_Draft_form_of_Agreement_Jan_2009.pdf (Accessed: January 2017)

►4) Health and Safety Executive (1976) *Final Report of the Advisory Committee on Falsework*, London: HMSO

►5) Hewlett W., Jones A., Marchand S. and Bell B. (2014) 'Re-visiting Bragg to keep UK's temporary works safe under EuroNorms', *Proc. ICE – Forensic Eng.*, 167 (2), pp. 58–68

►6) Health and Safety Executive (2011) *Preventing catastrophic events in construction* [Online] Available at: www.hse.gov.uk/research/rrpdf/rr834.pdf (Accessed: January 2017)

►7) Carpenter J. (2016) 'Temporary Works Toolkit. Part 2: CDM 2015 and the responsibilities of permanent works designers with regard to temporary works', *The Structural Engineer*, 94 (11), pp. 34–36

►8) Structural-Safety (s.d.) *About Structural-Safety* [Online] Available at: www.structural-safety.org/about-us/ (Accessed: January 2017)

HAVE YOUR SAY

To comment on this article:
►email Verulam at tse@istructe.org
►tweet @IStructE #TheStructuralEngineer