Temporary Works Toolkit

Part 1: An introduction to temporary works for the structural engineer

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.

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Temporary Works forum
Promoting best practice in the construction industry.

Tim Lohmann of the Temporary Works Forum introduces this new series and summarises some key differences from permanent works.

Introduction

The practice of temporary works is to consider the means by which a structure is transformed from one permanent condition to another. This can be from a green field to a finished building, from a completed structure to a brown field, or from one finished condition to another. The basis of the practice is to design a process that enables the transition between these states, and often several intermediate conditions, without overloading the permanent/retained structure. There are, however, many elements to consider throughout the process that have an impact on the range of solutions that are practical.

What relevance does temporary works have to the practising structural engineer? Without a consideration of how a structure is to be constructed, used and then demolished, it is hard to demonstrate that we have discharged our duties under the Construction (Design and Management) Regulations. An understanding of the issues affecting the design of structures in the temporary condition is vital if we are to make that consideration. Similarly, an understanding of the range of possible solutions is important to be able to design out risk.

This article is intended to be an introduction to the field of engineering in temporary works, and to provide a starter for a series of articles on the topic to be published in *The Structural Engineer*. Articles in the "Temporary Works Toolkit" will serve as a taster for each topic, with guidance on what the challenges are and where to go for further advice.

So, how does temporary works design differ from permanent works design?

Exposure to risk

The usual approach in structural engineering is to look at the risks to a structure over its lifetime and to ensure that appropriate resilience is provided for each of these risks. For permanent works, the lifetime is relatively long and so dominant events with a large return period can govern design; similarly, issues associated with durability, vibration and fire are significant challenges.

In the temporary situation, the timescale is different and the loading spectrum is such that the systems can experience a much higher proportion of their design load; issues with durability, vibration and fire are much reduced in significance. However, we are often working with structures that are stiffness critical and susceptible to significant loads from thermal and second-order effects. Similarly, the imposed loads can be large compared with self-weight.

Many of the challenges are about reducing exposure to risk by selecting appropriate methods and tools. For example, increasing the stiffness of a facade-retention scheme by increasing the size of the sections will reduce movement due to the design loading, but will also increase thermal movements; whereas changing the geometry can increase the stiffness without increasing scheme weight or thermal movements, and can also reduce foundation loadings. There is a similar debate about the use of large plant and whether it is better to use more machinery and fewer operatives, and so reduce the exposure of individuals to work in a hazardous environment.

Loads in temporary works

The loads that structures experience in the temporary condition are often significantly different from those that they experience in the permanent condition; similarly, they may have different geometrical constraints and so behave differently.

At one end of the spectrum, we may be loading a structure in the temporary condition in a vastly different way to that in the permanent state. For example, during demolition, excavators are often used on suspended slabs and this may not be a

condition that they have been designed for. We may also be looking at (for example) plunged columns in a building structure which are forced to work with a much longer effective length than in the permanent condition, or a core being constructed which does not have the permanent torsional restraint available from surrounding slabs. Foundation moments from tower cranes in the order of 10MNm and bearing pressures during piling of 600kPa are not unusual and so we need an appropriate reference frame for what the "right answer" looks like. It is only by sharing near misses and possible failures that we can work together as a community to identify problem areas and develop robust solutions for dealing with them.

However, at the other end of the spectrum, we can be looking at forming new openings in a lightly loaded wall, but in a structure with delicate finishes where the sequence of work and how load is transferred can be more significant than the strength of the system.

Wind loads are significant in temporary works and the effects from surrounding buildings on local actions associated with proximity to the end of the walls can become dominant in structures such as facade retentions and hoardings. Loads from retained soils are one of the biggest issues and the selection of appropriate parameters for short-term behaviour can lead to substantial savings if suitable methods are used for mitigation.

We can also get very high local loads from outriggers, props and restraining structures which need to be distributed back to suitable supports and foundations. The subject of impact loads – for containment of traffic, for providing resilience during construction and for protective structures – is currently being debated and guidance is in preparation.

Achieving stability and resilience

In any mature structure, there are established load paths that distribute the lateral loads down through the stiffer elements to the foundations. In new structures, these stability paths can generally be easily established and constructed ahead of or in line with the rest of the structure. In demolition or refurbishment, this opportunity may not be there and alternatives need to be developed prior to the removal of the existing load paths. The stiffness of these alternatives needs to be considered. Modern buildings are required to have extensive tying arrangements to avoid progressive collapse, but those constructed before the Ronan Point collapse (in London in 1968) and the subsequent revisions to building regulations may not be as robust, and so the possibility of progressive collapse during the works should be considered.

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In temporary structures, we are normally dealing with statically determinate structures with little or no redundancy, and so the structures have little opportunity to redistribute load in the event of a local failure. As such, elements should be designed so as to be robust when subject to accidental loads, or alternative load paths should be provided in the event of an accidental loss of a member.

Similarly, the incomplete structure is often much less stiff than the permanent scheme, and so movements can be larger and second-order effects correspondingly large.

Ensuring strength

Once we have established the loads we are carrying, and how the structure is stabilised, the required strength and stiffness of individual members can be derived and these can subsequently be designed. There is a lot of debate in the UK temporary works community about how the current design codes (Eurocodes) can be applied; hopefully, the recently issued PAS 8812[1] will clear up a lot of misunderstanding.

The design of elements in temporary works is very much the same as in permanent works, although we may take larger eccentricities and lower material strengths where we are less certain about the arrangements. Where standard components such as strongbacks or proprietary props are used, the capacities of these are normally given compared to a safe working load. This is an outdated concept but useful for simple schemes. One of the challenges in the industry is getting suppliers of proprietary equipment to provide characteristic capacities for these components and assemblies.

Foundations

All temporary works loads need to get to a supporting medium. These can be an existing structure or foundation, a new foundation or perhaps water for floating equipment. The issues with these foundations are the same as they are for a permanent structure – are they stiff enough and strong enough for the loads being applied to them?

The range of solutions and techniques here is wide and can include schemes from simple spread foundations to support dead shoring, to plunge columns into piles supporting continuously varying loads from, say, tower cranes that can change from compression to tension over seconds.

Much of temporary works is concerned with below-ground structures and how these are constructed. The challenges associated with reusing urban sites with existing basements are huge, fascinating and complex. When you add in interaction with external buried structures and services, we can very quickly get to systems that are very hard to model accurately.

Current challenges

Several issues recur and, while they may initially appear simple, there are often several different approaches to solving the problem:

- How do you build a concrete frame?
- Does ballast work?
- Are there some situations where we should be working within a safe working load environment rather than a limit state environment?
- How do you build a 2m deep capping beam on a boundary?
- How is reinforcement fixed?

Questions such as these will be explored in the series.

Summary

We believe that temporary works and construction method engineering is a fascinating field and that there is much for all of us to learn – both in understanding the processes and in how to deal with the challenges that arise. We hope that this series of articles will provide both useful tools for all engineers and a route into further enquiry in particular subjects.

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REFERENCE:

1) British Standards Institution (2016) *PAS 8812:2016 Temporary works. Application of European Standards in design. Guide*, London, UK: BSI