TW18.051
IStructE - History of Structural Engineering Study Group
Joint meeting with the Temporary Works Forum (TWf) – 24th April 2018
Summary of meeting

Temporary works and historic structures

This evening meeting (held at The Institution of Structural Engineers, International HQ, 47 – 58, Bastwick Street, London, EC1V 3PS, UK on 24th April 2018) comprised three presentations by members the TWf.

The History Study Group was set up to discuss historical aspects of structural engineering, particularly in relation to the evolution of present day engineering methods, to learn from history to solve today's problems and to understand old construction methods and materials.

Event chair:
Tim Lohmann, Chair, Temporary Works Forum (www.twforum.org.uk)

Event host:
Andrew Smith, Convenor
IStructE History of Structural Engineering Study Group
hsgconvenor@acsstructures.co.uk

1. Façade and Party Wall Shoring

Stuart Marchand[i]
Managing Director, Wentworth House Partnership

Stuart explained the importance of a number of aspects of façade and party wall shoring (CIRIA Report C579 provides useful guidance):

Party wall – a common wall between two buildings; generally supported by both buildings.

Façade construction:
- It is important to understand the materials from which the façade is constructed and its age/condition.
- Contractors work under extreme time pressure –façade retention design is usually on the critical path.
- The historic research into the façade is therefore best carried out by the client's design team.

General causes of defects – including: service installation; previous alterations; differential movement; subsidence/settlement; change of requirements; deleterious materials; corrosion; decay.

Typical defects in walls - solid walls delaminating (beware snapped headers); rotten bonding and other built-in timbers; unbonded junctions of walls; timber lintels/bressumers (even if sound, potentially deleterious if exposed to damp in the future); corrosion/absence of wall ties; walls not tied to floors/roofs; faulty boot lintels/beams; inadequate bearing of brickwork; out of plumb.

Stiffness of restraint system - deflections are generally limited to h/750; however, where a facade is built into the adjoining building this is disastrous and will lead to cracking at the junction; similar considerations also apply to a party wall where deflections need to be limited to 5 to 10mm (subject to agreement with party wall surveyors).

Coordination – sites are often bounded by roads and/or party walls; the temporary works need to consider the stability of the existing buildings during local demolition for temporary works installation; retained façade and party wall geometry; archaeology at varying depth; new basements and/or deepening; new foundations and structure..

Wind loading – BS EN 1991-1-4 Clause 7.4.1 Table 7.9 gives pressure coefficients for freestanding walls and parapets.

Stability loads – C579 recommends the greater of 1.5% of all vertical loads, or out of plumb and offset effects plus 1.5% of applied vertical loads (i.e. excluding self-weight of façade.). This is to be considered as uniformly distributed over the façade surface. Note that for local fixings to the façade 2.5% of the weight of façade above the level being considered must be taken.

Other loads:

- Dynamic effects from plant are not usually a design consideration. Long reach plant should not be used close to a façade as it is capable of moving the façade and causing damage.
- Impact loads must be considered: Recommended as 10 kN from 1m above ground level and 25 kN below. Traffic should be kept away from a façade retention system.

With to help of slides from past jobs, Stuart concluded by illustrating different possible layouts of façade retention systems.

----

2. Buxton Crescent Hotel - a Grade I listed building from the 18th Century

Cristina Orgaz[ii]
Senior Engineer, Tony Gee & Partners LLP

Cristina gave an overview of just two aspects of a project that she has been working on for 2 years; helping the main contractor to achieve the permanent works design. These illustrated the type of challenges that designers deal with.

The site

Buxton is a spa town in Derbyshire, inside the Peak District National Park. It has its Crescent and also natural baths, hot baths (now a shopping centre), The Square (flats) and Old Hall Hotel (the oldest hotel in England, apparently).

A map (1879) shows the Crescent and adjacent buildings sharing not only walls, but basement rooms. The Crescent's Architect was Jon Carr. It was originally designed as hotel (1780 to 1788). The baths were proposed in 1852. The Royal Crescent in Bath is 150m long. This one is smaller, at 95m. All the rear annexes where demolished in the 1990s.

The architect, under the Duke of Devonshire's orders, placed the hotel at the bottom of a slope/valley called the Grove – a steep limestone hill - where the River Wye had flowed for many years. A culvert was built to lead the river away from the building. The building has high levels of ground water and has had overflow periods.

Thermal water runs under the buildings. The famous Buxton Spring Water runs at around 28 degree. These are constantly collected (bottled and sold), even during the refurbishment of the buildings! Accordingly, very strict controls on site were implemented to avoid disturbing the current flow or contaminate the springs. The number of boreholes was limited, as well as keeping constant vertical weight, wall underpinning, new excavations, etc.

The future hotel will comprise: the Crescent (a Grade I listed building from the 18th Century); and the Thermal Spa (a Grade II listed building). Both, in conjunction with a new annexe building, will form part of a 5* hotel with 80 rooms and luxurious baths.

Historic England was keen to save as much as possible of the original elements, e.g. cast iron; cantilever stone staircases; chimneys; balustrades; doorframes; plaster finishes.

Cast iron structure (Ladies Pool)

An original cast iron structure supported a roof light in the Ladies Pool. The final design required the existing roof to be demolished and replaced with a new reinforced concrete slab at a higher level. The pool itself was to be replaced too.

The cast iron (CI) needed to be repaired and left as a decorative feature, in its original position.

The new reinforced concrete (RC) roof was required to be demolished at an early stage in the program, so there was very little time available to investigate options of how to take the cast iron out and put it back in again. Also, with all the surrounding buildings, it was difficult to find a crane position.

After discussing a few options with the contractor, it was decided to leave the cast iron in place and clean/repair it on site.

Once the existing roof was gone, some non-intrusive site investigations were requested to examine the column base and look more closely at the capitals (and any possible joints).

It was decided to hang everything from the top. The new RC slab was poured, leaving cast in sockets. Once cured, everything was hung from the base of the columns (and by avoiding contact with the lace beams; as it was unclear how and whether the capitals where connected to the columns). Everything was suspended for around 3 months. Later, the masonry pool was demolished and CI re-supported.

The roof

The contractor needed to lift up the roof cover and replace the waterproofing. It was planned to complete the front first, lodge by lodge (in between chimneys). The contractor erected the front façade access and cleaned the stones so it was really easy to reach the roof from here. Without the weight of the slates and completely opened the wind forces generates a ‘canopy effect’, that was not there before.

At the same time it was necessary to cut out the top chords of one of the central trusses to allow construction of the new dormer windows. All the original timber connections were like this, i.e. dry connections. Therefore, there is little or no tension capacity. 3D modelling was used to check the different stages and load cases.

A temporary load path was created, by installing ratchet straps, in order to restraint the uplift forces and maintain global stability of the roof during the works. Timber elements were tied in all three orthogonal directions. New glulam beams were craned in to form the new dormers.

West Pavilion roof

There was a need for a very large number of timber repairs, in this case the roof covering was kept in place at all times.

Most of the end bearings needed to be replaced due to dry root (top and bottom chords). Each splice took at least seven days to cure and, of course, the contractor wanted to complete as many repairs as possible at the same time!

With the removal of three or four bearings at the same time, the tension loads redistribute and, suddenly, the purlin connection is no longer capable of taking the loads; and some members experienced tension where they hadn't before. Accordingly, the structure was temporarily reinforced with ratchet straps and hangers.

Other aspects

Checking the roof was one thing, but everything else around had to be considered. For example:

- As the end bearing goes off, the structure itself needs to be supported vertically too, to avoid displacements!
- Aluminium props were used as they are light and easy handled into the building using the stairs.
- Care was needed when assuming prop capacities as the buckling length can easily change
- Cornice stability when the truss reaction is no longer there.

----

3. Surgery to a vital artery
   Hammersmith Flyover - Phase 2 - Long Term Refurbishment
   Andrew Stotesbury[iii]
   Laing O'Rourke – Tideway Central, London

Background

Andrew explained the site location; the nature and scope of the works and the project activities. Some items were removed from the original list, but many more were added as the project proceeded. The flyover was built in the 1960s using a revolutionary system of post-tensioned precast segments.

Damage to the ageing 1960s structure had been caused by water ingress, including salt water due to grit laid during the winter months, which had corroded and weakened the cables which help support the flyover. It was considered that there was a very remote possibility that the flyover would collapse.

The bridge was on the 'Olympic Route Network' connecting key participants between Heathrow and central London, for London 2012.

Scope of work

The work included:

- New tensioning cables – totalling 6.5km in length – installed and fully tensioned, restoring strength within the structure
- The entire flyover re-waterproofed and resurfaced with new drainage installed within the structure
- More than 150 tonnes of steel beams and bars installed inside the flyover to hold the new tensioning system and reinforce the concrete
- Two five-tonne expansion joints within the carriageway were replaced, allowing the structure to flex as traffic moves across it
- Replacing all 34 bearings supporting the flyover, allowing it to adapt to weather conditions and expand in the summer and shrink in the winter by up to 180mm

Early Contractor Involvement (ECI)

The ECI phase provided an opportunity to understand fully the scope of works. This included how to move around safely inside the bridge ('tunnel'). Different options were examined for the site setup; including crane platform arrangements; site hoardings. New temporary works proposals were developed, including: logistics, safety, de-risking the schedule of work. Full-size part-span mock-ups were constructed: concrete segment; typical bearing pit. The flyover was kept open to traffic for more than 90% of the duration of the work.

The key to success

The project required deep collaboration between all the different parties involved. There was no clear division between staff and Andrew considered this key to the delivery of a project of this scale, complexity and timescale.

Presenters

i

Stuart Marchand:
Biography:

Stuart graduated from Cambridge in 1973 and spent the majority of his first 8 years of experience in heavy civil engineering on road and bridge construction and on the Thames Barrier. He then transferred to the temporary works design sector of the industry and joined Costain construction's temporary works department as Senior Design Engineer. He progressed to take over as Chief Engineer in 1991 and was involved in many major developments with deep basements, e.g.: 7-storey underground car park in Aldersgate (on which he published two papers); and 12-15, Finsbury Circus (a 16m deep open-cut basement). In 1999, he left to set up Wentworth House Partnership which he has developed as a specialist temporary works consultancy, now comprising a staff of 45. He is currently working on a revision to the CIRIA Guide C654 on tower crane foundations, in order to bring it into line with Eurocodes.

ii

Cristina Orgaz
Biography:

Cristina arrived in the UK six years ago from Madrid, Spain. Her initial background comes from architecture and planning, as she is an Architect - but she is a Chartered Civil Engineer too. Cristina has over 8 years of experience with different backgrounds and technical competencies and, currently, she is working as a temporary works designer.

iii

Andrew Stotesbury
Biography:

With an engineering career starting with George Wimpey & Co. and progressing through sub-contracting, temporary works equipment supply and progressing into temporary works coordination and management with: Mowlem, Costain and currently Laing O'Rourke, Andrew has a wealth of temporary works experience. This includes new build and extensive experience of refurbishment of historic and listed buildings. This experience was just one of the ingredients to the success of the refurbishment works to the Hammersmith flyover project.