



Hammersmith Flyover - IIP Design Case Study



Project Summary

Hammersmith Flyover was constructed in the early 1960's and is situated in West London. The flyover itself lies within the boundary of London Borough of Hammersmith and Fulham. The 622m long structure comprises sixteen spans, with a post-tensioned segmental deck with integral piers, supported on roller bearings at the base. An expansion joint located at the seventh span from the west abutment divides the flyover into two separate continuous structures.

Contractor:	Costain LTD
Client:	Transport for London (TfL)
Case Study Ref. No:	CE0001
Project Number:	4000
Publication date:	June 2015
Region:	London
Sector:	Infrastructure
Contract value:	Confidential
Project timescales:	April 2013 - Summer 2015
Project Themes:	Integration, collaboration and value for money

1960's construction

Post tensioning tendons that run through the structure were found to have been deteriorating at a significant rate, affecting the flyover's ability to support live loads. In December 2011, following intrusive inspections, a higher than expected rate of deterioration of the post-tensioning tendons was revealed due to the ingress of water and salts. The Hammersmith flyover was closed under emergency conditions as a consequence.

Initial strengthening works were undertaken on five spans on the eastern end of the structure, using full and partial closures of the carriageway. This was the first phase of works, completed in summer 2012 prior to the Queen's Jubilee weekend and the London 2012 Games. Phase 2 (and final phase) of the works programme to refurbish and strengthen the remaining spans of the bridge has commenced on site and is planned to be complete in 2015.

Client & Project Objectives

The client, requiring efficiency and certainty of project delivery, engaged the Structures & Tunnels Investment Portfolio (STIP) framework contractors. The technically challenging Hammersmith project is demonstrating how efficiency can be achieved with respect to cost, time and quality while minimising the impact on local communities and road users. Achieving a 120 year design life on the new elements, simplifying inspection and maintenance regimes have been a principal focus to reduce whole life expenditure.

Given the complex technical solution required to strengthen the flyover the client engaged the contractor and specialist supply chain early in the design development phase. The engagement process (Early Contractor Involvement – ECI) included co-location of the client, designer, contractor and the specialist contractors for both tendon and bearing replacement. This approach allowed the most innovative and cost effective solution to evolve.

The procurement process has allowed Costain, the main contractor, to expose and resolve the key project risks with support from the supply chain. As such the team was able to take ownership of this design and build contract with confidence and certainty of delivery.

The project specific success criteria focus on Health and Safety, customer satisfaction, time and people as listed below.

Safety, Health and Environment

- No Fatalities
- Zero Reportable Accidents
- No HSE, EA or EHO notices
- A Healthy Workforce
- Environmental Excellence

Customer Satisfaction

- Exceed TfL Expectations
- Minimised Disruption to the Public
- Positively Engage with the Local Community
- Responsible Procurement

Time

- Deliver Key Milestones on Time
- Completion on Time

People

- To Attract, Retain and Develop the Best People
- To be a High Performing Team Fulfilling their Potential
- For All to Enjoy their Work

Lessons learnt from this project will be captured and used to inform and improve future contracts and outcomes within the STIP Framework for TfL, Costain, Ramboll, Parson Brinkerhoff and supply chain teams.

Integrated Teams

Transport for London has actively promoted the adoption of an Early Contractor Involvement (ECI) and New Engineering Contract to focus the project team on collaboration and integration. The project is actively demonstrating how this model drives innovation, efficient delivery and value for money on a time constrained scheme. The requirement for a highly innovative technical design and construction solution has driven the adoption of best practice processes and methods. This has included the use of 3D, 4D and 5D Building Information Modelling (BIM), the use of Asite, handheld tablet based quality systems, comprehensive stakeholder and community engagement and an extensive apprentice and training programme.

The enablers to this success have included an overriding client commitment to collaboration, early design team and contractor integration and co-location using common systems and processes.

Project Description

The project to strengthen the flyover can be divided into two principal sections – above deck construction and below deck construction. Each of these sections is described in more detail below:

Above deck construction

To meet the specified design life requirements the existing road surface has been removed to expose the existing structure. The deck has been progressively re-waterproofed and resurfaced. Works include installation of a new drainage system, a concrete safety barrier as well as innovative hydro-demolition techniques to facilitate and integrate the construction of long tendon anchors into the existing structure.

Below deck works

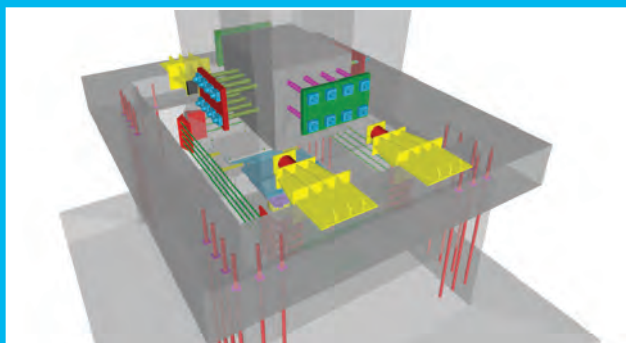
The scope below deck level is principally post tension cable replacement, pier bearing replacement (plus pier walls) and base foundation strengthening.

Post tension cable replacement



The design solution adopted replaces the corroding tendons with new tendons running both internally within the existing flyover structure and externally along the length. Internal tendon replacement includes pier head strengthening works.

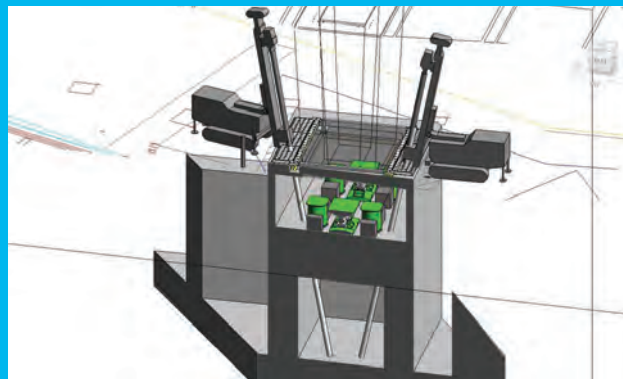
Pier bearing replacement



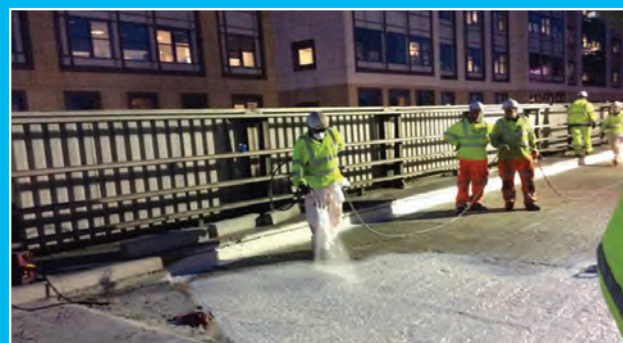
This involves temporarily supporting the existing pier whilst the existing bearings are removed and the new bearings

installed. The temporary works supporting the pier has to respect the flyover's operating movement requirements. The bearing pit capping beam has been strengthened to achieve this and monitoring devices identify any excessive movement during the critical stages of bearing replacement.

Foundation strengthening



Foundation strengthening has included the removal of unclassified fill materials and subsequent replacement in two of the bases. Vacuum extraction techniques have been used to achieve this.



Deck Waterproofing



Temporary Movement Joint Installation

Constraints & Challenges

The project team has tackled many constraints; the obvious include the nature of the flyover, which is adjacent to the Hammersmith gyratory and LUL (London Underground Ltd). All are arterial traffic routes into and out of the Capital and has meant the works are being carried out without any peak time road closures. Space is at a premium given the need to maintain traffic flows and minimise disruption to the local area.

Lack of space within the bridge, which tapers in depth as it spans between adjacent piers, represents a challenge. Managing work activities within this confined space requires meticulous planning and preparation.



Internal view of the flyover

Finding solutions to achieve the proposed scope of work has been complex. No design standards exist to support the team to specify the remedial works to this existing post-tensioned structure. Design solutions have developed to embrace current design standards applied to the fifty-year-old structure. In addition the team has been challenged when as-built records do not reflect the existing conditions or when design solutions have not been transferrable to other parts of the structure where a common solution should, in theory, be appropriate.

Elements of the project are adjacent to and above London Underground infrastructure. Working at night helps minimise the impact on the traveling public when carriageway closures are required. Stringent sign off procedures, along with a competent and trained workforce, ensure the highest levels of safety have been maintained for the travelling public during pier strengthening activities and pier bearing replacement.

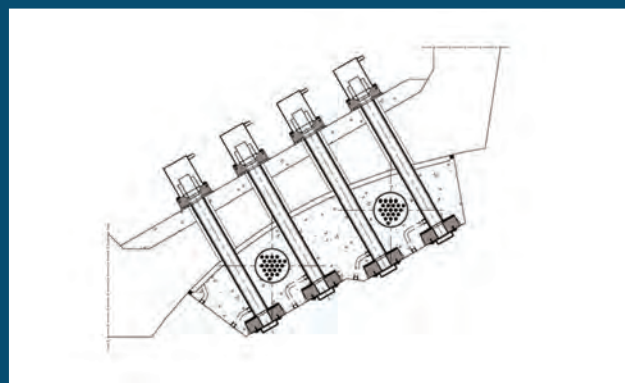
As the design unfolded it became clear conventional design solutions would not satisfy the requirements of this project. Resolving the design for this unique structure has meant the need for innovation.

Innovation

The project team has embraced innovative processes and solutions; a laser scan of the entire structure and three-dimensional modelling has helped visualisation during the early design development stages. Collaboration across the design and supply chain has ensured the safest and most practical solutions have been developed. The use of ultra-high strength concrete, to resolve the challenge of supporting the external tendons, is one example of a successful output through collaboration between the specialist contractor and design team. Equally the construction management team has been tested to solve the associated installation challenges.

Ultra High Performance Concrete and external tendon design

The design team identified the need to locate some of the replacement tendons externally. Given existing tendons cannot be removed before new are installed, space within the structure is a premium. The existing structure was not designed to support external cables; additional structure has to be added in the form of concrete blisters to connect the new cables to the bridge. The new strengthening solutions had to be as compact as feasibly possible to minimise the impact on the existing structure. Concrete backing slabs have been added to the inside of the sloping bridge deck sections for strength to support the external blisters which are connected by bolts through the bridge deck slab. One hundred and ninety two blisters and two hundred and thirty two supporting slabs have been added to the existing structure.



A section through bridge deck & blister



An orthogonal view



The blisters insitu prior to cable installation

Ultra High Performance Fibre Reinforcement Concrete (Ductal®) – is a Lafarge product developed for projects that require complex structural solutions. The product has unique strength, durability, ductility and aesthetical properties due to an integrated fibre. The product has improved resistance to abrasion, chemical resistance, freeze-thaw, carbonation and chloride ion penetration, making it well suited for construction in aggressive environments.

The fibre reinforced concrete provides “ductility”, which means that it can bend and carry large loads without brittle or sudden failure. The ductile failure of Ductal® closely resembles the failure mode of metals rather than concrete. Because of its combination of strength with ductility, a solution designed using Ductal® has been achieved without the use of passive reinforcement (reinforcing steel), which will result in smaller sized members and faster construction times.

Typical Ductal® concrete strength ranges from 130–190 N/mm² significantly higher than traditional concrete mixes.

Installation

The construction team’s challenge was how to install the blisters and pour the concrete given the spatial constraints, geometry and installation tolerances.

Bespoke lifting equipment has been designed and manufactured to meet this challenge. A mock up of a bridge section has been created off site to allow the site team to practice the blister and concrete installation.

The mock up has also helped the team develop safe working procedures within the flyover structure through training and project induction. And allowed a testing regime to demonstrate the success of the design solution.

Concrete pours have required the use of Perspex shuttering inside the bridge structure to monitor concrete pumped into the structure using an innovative syringe system.



Blister installation at the mock up site



Perspex shutters within the bridge desk structure

Environmental Considerations

The project team has optimised the use of off-site manufacture and pre-assembly to minimise waste and reduce the impact of the project on the surrounding community. The team has reduced vehicle movements to the minimum through the use of a remote logistics depot.

Testing off site has been adopted to avoid unnecessary waste and the consequences.

Corporate Social Responsibility

Transport for London has been focused on supporting the local community. They were keen to ensure local residents and stakeholders had visibility of the proposed construction works to allow an open dialogue with those affected. A local community liaison officer has been appointed by the project to achieve this aim. A comprehensive communication and community engagement plan has evolved facilitating an open and honest relationship with the community.

The project team has sourced local labour and materials where feasible. Eleven apprentices have been appointed by Costain and a further ten apprentices have been appointed by the wider supply chain. Whilst gaining valuable experience working on the project the apprentices also spend time in the classroom working toward NVQ qualifications.

Occupational healthcare has been provided on site 4 days a week. Health campaigns and monitoring have focused on vibration, muscular skeletal checks, lung capacity, heart rate check and diabetes. A reporting process allows the management team to monitor overall and individual health issues.

Safety has an equally high priority, staff training has focused on behavioural safety; promoting and developing positive consequences to influence positive action.

Social events have been a key element to team cohesion and unity. Workshop and whole team events have facilitated communication across the team creating trust. An open book approach to commercial management underpins this culture.

Performance / KPI's

The project team has agreed a number of key performance indicators with the client, TfL. These include:

- Health and safety
- Financial
- Customer
- Quality
- Supply Chain
- Time
- People

These areas will be monitored over the course of the project and form part of the lessons learnt section of the final case study for this project to seek continuous improvement through action plans.

References

www.ductal-lafarge.com/wps/portal/ductal/2-Structural

**Constructing Excellence,
2nd Floor, 33 Queen Street,
London EC4R 1AP**

T: 0845 605 5556

E: helpdesk@constructingexcellence.org.uk

www.constructingexcellence.org.uk

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