The seemingly never-ending job of painting the Forth Bridge is coming to an end. The logistics and challenges behind the successful conclusion of the 10-year project to restore the bridge are outlined by John Andrew, the Business Development Director for Balfour Beatty Regional Civil Engineering, the principal contractor for the Forth Bridge Restoration Contract.
December 2011 saw the completion of a decade-long project to repair and completely repaint the Forth Bridge for the first time in its 121 years of operation. The restoration works involved one of the largest-scale tasks of its kind, featuring innovative scaffolding techniques and encapsulation methods that have since been replicated on many large civil engineering and building projects.

The Forth Bridge, which opened in 1890, had never before been subjected to this level of treatment. The logistics for this £130 million project, on the world’s first cantilever and Britain’s first all-steel bridge, were complex and carried out mindful of its protected status as a Grade A listed Victorian engineering icon. The entire 53,000 tonne bridge, standing over 110 metres above high water to the top of each cantilever, was stripped back to bare metal. Repairs were carried out and the latest surface coating materials, developed with technology employed on North Sea oil installations, were used to recoat the bridge to provide long-term protection for the structure. An additional challenge was posed by the need to undertake the works with minimal disruption to rail services and in all weathers on a five operating structure which can carry up to 200 train movements daily over the 2.5 km length of this key strategic transport route.

The physical work began in 2002 and grew year-on-year as what was effectively the completion of this unique structure. Balfour Beatty implemented comprehensive procedures and systems to ensure safe and controlled workspaces at all times. This required the construction of an encapsulation system to maintain factory-like conditions for the works to be carried out in a protected environment. At the same time, it had to prevent any contamination of the Forth of Firth by retaining the grit-blasting materials and paints within enclosures.

The scaffolding and encapsulation on the Forth Bridge enabled access to every square metre of the structure, whilst also maintaining full economies of scale. New compounds – with enhanced with the use of a road/rail vehicle (RRV) which could both pull rail wagons and other supplies to strategic points on the bridge during a ‘possession window’ from the storage yards at the south side of the bridge, via walkways remote from the permanent way railway line, were installed to provide dedicated ‘green zone’ separation from the operational railway. In many areas, this involved adding additional elements to the main bridge framework.

SPECIALIST SKILLS

The paramount safety demands dictated that operational railway safety trained supervisors were on duty to control these weekly events and on any other occasion when the specially-qualified workforce crossed the railway line to undertake specific tasks. Many of the Balfour Beatty team worked on this project from its inception through to completion and for many it has become a career-defining experience. These people have come to see the bridge as their ‘home’ and as more than just a place of employment, taking huge pride in what they have contributed to the restoration.

SCAFFOLDING

Design and erection of safe systems of access to all areas of the complex bridge structure, whilst also maintaining full locations. The RRV also assisted the removal of materials and redundant equipment at the end of each shift.

If repairing or improving something is like painting the Forth Bridge, it takes such a long time that by the time you have finished doing it, you have to start again. ‘Home improvements are a bit like painting the Forth Bridge. By the time you’ve finished the kitchen, the bathroom needs decorating and so it goes on.’ Cambridge International Dictionary of Idioms © Cambridge University Press 1998
At all times during the restoration process, the structural integrity of the bridge was the primary consideration as the weather-resistant plastic membrane could have acted as a ‘sail’ and created additional wind loads to the structure. Just as importantly, the residue produced by the blasting process was contained to prevent any contamination of the Firth of Forth below, the external atmosphere or the local area which is home to a number of sensitive environments, including nature reserves, breeding colonies and sites of special scientific interest. This encapsulation solution has since been employed at Heathrow airport, Selffield and the neighbouring Forth Road Bridge and has attracted interest internationally from companies undertaking similar projects.

**WEATHER**

The elements posed a constant challenge as the Forth Bridge can experience the weather of all four seasons in one day, with conditions changing in a matter of minutes. Supervisors regularly checked that wind speeds were within agreed limits to ensure safe working conditions. When necessary, the scale of the bridge allowed the workforce to be relocated or, in extreme conditions, taken off the bridge and allocated other off-site tasks. Work on the project continued without major disruption throughout an exceptional range of weather conditions, including two of central Scotland’s most prolonged and coldest winters on record.

The next challenge was posed as the scaffolding could not be assembled and supported as in a normal construction site, environment, that is to say from the bottom up and to regular geometric principles. Few of the scaffolds were built on traditional footings but were instead connected to the structure through additional pads and support points welded to the steelwork. Scaffolds were then supported from these points and either built up, constructed from the top down or, in certain circumstances, suspended from steel wire ropes connected to the higher points of the bridge steelwork. Lighter materials were widely introduced to improve weight distribution as the agreed some 4,000 metric tonnes of scaffolding was in use on the bridge at any one time. Extensive use of aluminium scaffold tube, both in standard linear form and unit beam configuration, together with the use of recycled plastic scaffold boards on walkways and access routes, in place of traditional timber boards, helped to ease the load.

**LOAD MODELLING**

At all times during the restoration process, the structural integrity of the bridge was the primary consideration as the weather-resistant plastic membrane could have acted as a ‘sail’ and created additional wind loads to the structure. When necessary, the scale of the bridge allowed the workforce to be relocated or, in extreme conditions, taken off the bridge and allocated other off-site tasks. Work on the project continued without major disruption throughout an exceptional range of weather conditions, including two of central Scotland’s most prolonged and coldest winters on record.

The next challenge was posed as the scaffolding could not be assembled and supported as in a normal construction site, environment, that is to say from the bottom up and to regular geometric principles. Few of the scaffolds were built on traditional footings but were instead connected to the structure through additional pads and support points welded to the steelwork. Scaffolds were then supported from these points and either built up, constructed from the top down or, in certain circumstances, suspended from steel wire ropes connected to the higher points of the bridge steelwork. Lighter materials were widely introduced to improve weight distribution as the agreed some 4,000 metric tonnes of scaffolding was in use on the bridge at any one time. Extensive use of aluminium scaffold tube, both in standard linear form and unit beam configuration, together with the use of recycled plastic scaffold boards on walkways and access routes, in place of traditional timber boards, helped to ease the load.

**LOAD MODELLING**

At all times during the restoration process, the structural integrity of the bridge was the primary consideration as the weather-resistant plastic membrane could have acted as a ‘sail’ and created additional wind loads to the structure. Just as importantly, the residue produced by the blasting process was contained to prevent any contamination of the Firth of Forth below, the external atmosphere or the local area which is home to a number of sensitive environments, including nature reserves, breeding colonies and sites of special scientific interest. This encapsulation solution has since been employed at Heathrow airport, Selffield and the neighbouring Forth Road Bridge and has attracted interest internationally from companies undertaking similar projects.

**BLASTING AND PAINTING**

One of the most extreme jobs of the restoration process was undertaken by blasters wearing protective clothing and helmets incorporating a head set with an umbilical cord containing an air line, communication link and power line for tools and lights. The grit used in the blasting process was a byproduct of the copper industry – very hard, but inert. Stored in bulk in the main storage areas at the base of the bridge cantilevers, it was then mixed with air provided by large banks of compressors situated at the north and south compounds.

Industrial vacuum extraction units then removed the grit and other debris at a rate of up to 20 tonnes of material per hour. By modifying internal workings such as the vacuum governors, the extractor’s pull capability was expanded from a standard 200 to 500 metres, essential when work areas were often a considerable distance from the collection points sited at the base of each cantilever. From there, waste was bagged and moved by barge back to land and then on to recycling centres and licensed disposal sites. Here the grit was treated, paint and rust removed for disposal in approved facilities, with the cleansed grit available for reuse.

Finally came the paint, developed specifically for use on the Forth Bridge by Leighs Paints of Bolton, a 190-year-old family business which recently became part

---

**Scaffolds were employed to construct and remove the complex systems. © Balfour Beatty**

---

**View from the top of the Firth cantilever looking south showing scaffolding and encapsulation. © John Andrew**
John Andrew is an engineer and Business Development Director of Balfour Beatty Regional Civil Engineering. He has extensive experience of all forms of civil engineering projects during his 30-year career.

The author would like to thank Ian Heigh, Network Rail; Colin Hardie, Balfour Beatty; and Gary Atkins, a freelance writer, for their help in the preparation of this article.

Bolton-based Leighs Paints developed the Forth Bridge paint system with technology employed for the offshore oil industry. The system essentially bonds with the metal to stop moisture getting through. The finish coat, Transgard TG168, has good colour and gloss retention properties, is expected to last 20 years and is indefinitely recoatable. The skim section shows the comparative thickness of the second coat and TG123 Glass Flake. The picture above shows lab manager Carl Burrell testing the 'Forth Bridge Red' paint.

Finally the trademark topcoat, in the form of 50microns of Forth Bridge Red paint, was applied – mixed to match the original red oxide colour used in 1890. The epoxy paint applied in the first two coats does not provide good light resistance, so the final coat was of acrylic urethane, giving good colour stability and gloss retention along with an indefinitely recoatable surface to keep preparation to a minimum for future maintenance works.

Following inspection and approval of each completed section, the task of dismantling and removing all the scaffolding, encapsulation and support services was systematically undertaken and the rolling restoration programme moved on to the next area.

AN END TO CONTINUOUS PAINTING

This pioneering project has used some 240,000 litres of paint to completely recoat the bridge in a single operation for the first time since its construction. Train passengers and the many visitors to the shores of the Forth will now enjoy uninterrupted views of this most photographed of bridges. It is important that the bridge looks its best now that it is under consideration for UNESCO World Heritage site status. Whatever the outcome, the use of modern technology now protects this iconic feat of Victorian engineering and much-admired Scottish landmark as the Forth Bridge continues to serve into the 21st century.