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CINTEC ANCHORS FOR HISTORIC BODIAM BRIDGE

Cintec anchors for historic Bodiam Bridge

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Introduction

The Highways and Transportation Department of East Sussex County Council is responsible for the maintenance of the 200 year old brickwork arch bridge adjacent to Bodiam Castle. In recent years this has suffered from the effects of increasingly heavy traffic exacerbated by very cold winters in 1986 and 1987. This led to cracking of brickwork adjacent to the arch voussoirs, some movement in the spandrel walls and delamination of the wing walls at the south end. The County Council approached Cintec International with a view to using Cintec anchors for tying across the arch.

Typical damage to the soffit of the bridge

History

The crossing of the river Rother at Bodiam, midway between Tunbridge Wells and Hastings, has a long history. The site is that of a Roman road, constructed on a twigs and rubble causeway to serve an ironworks. Until the 13th century the surrounding alluvial plain was under a shallow depth of brackish water as much as 420m wide, and for some time crossed by a ferry. The first reference to a bridge on the site is in 1385, and the present bridge was built in 1797 for the County of Sussex by Richard Louch for £1150.

The bridge is a single track, hump-backed triple arch structure in brickwork and there are signs of various remedial works throughout its life. There appear to have been problems with the original construction for there is pronounced twist in the

Core drilling holes for the anchors

Placing the anchor in the prepared hole

lower courses of brickwork towards the northern end of the bridge, which disappears as the construction continues upward. Presumably this was due to some of the timber piling settling during construction. The cast-iron end bosses of previous ties between the spandrel walls can be seen on both elevations. In 1980 an inspection carried out by divers revealed that the timber piles on which the bridge is founded had become exposed and were deteriorating. In 1982 a concrete filled Fabriform mattress was installed to provide a solid invert and protect the foundations of the bridge. Also in 1982 the approach ramps to the bridge were filled by up to 200mm to minimise the hump. A principal inspection and assessment in 1989 concluded that remedial works to the arch rings and a weight limit of 17 tonnes were required to prevent further deterioration. This weight limit remains in force after the remedial works have been completed to preserve the bridge but will still allow coaches over to visit the adjacent Bodiam Castle, a National Trust property.

The most recent remedial work involved the repair of cracking in the brickwork. The concentration of the damage in the two side spans of the three span bridge suggested that the initial cause was possibly impact loading towards the ends of the bridge before the 'hump' was levelled out in 1982. This impact loading will have had the effect of forcing out the spandrel walls. Frost damage during the cold winters of 1986 and 1987 and washing out of mortar have further developed the initial effects. This has led to cracking of brickwork adjacent to the arch voussoirs, some movement in the spandrel walls, and delamination of the wing walls at the south end.

In view of the historical context of this attractive small bridge, East Sussex County Council was concerned to find an effective means of tying, with minimum visual impact, across the arches, within the thickness of the arch brickwork, Cintec anchors offered the possibility of bonding along the full length of the anchor without an unsightly external anchorage or problems with grout losses through the cracks in the arch.

Cintec anchors

The Cintec Anchor System comprises a steel section in a mesh fabric sleeve into which a specially designed cementitious grout is injected to achieve the completed anchor. The material of the sleeve is selected to retain the solid constituents of the grout while a bonding agent incorporated within it is forced out through the sleeve to provide a positive bond to the parent material. The grout cover to the section and the extent to which the completed anchor conforms to the contours of the hole in the parent material can be controlled by the size and stiffness of the sleeve used. Typical applications to date have been based on the use of stainless steel structural sections up to 30 x 30 x 3.0 SHS, but the use of larger carbon steel anchors is currently being investigated.

The use of Cintec anchors for Bodiam bridge gives a number of major advantages over conventional cement or resin grouted anchors. Conventional grouted anchor systems can have problems in the grouting, and there are doubts about the effectiveness of the anchors, when large volumes of grout are lost into voids within the

Bodiam bridge after completion with the castle behind the trees in the background.

structure, or escape through cracks. Bodiam bridge, with its cracking and deteriorating joints, provides a good example of the potential problems. But in the case of Cintec anchors the sleeve limits the travel of the grout and ensures that the holes are filled and effectively bonded to the parent material. This capacity to constrain the grout can be used to tailor the anchor to the material in which it is to be placed: for maximum bond in weak or voided materials a generous sized sleeve of relatively flexible composition can be used with lower grout pressures; in stronger and more homogeneous parent material, a smaller diameter and stiffer sleeve allows higher grout pressures for longer anchor lengths, more economy in grout use and probably greater direct bond. With conventional anchor systems the gap between the tension element and the inner face of the drill hole has to be kept to a minimum to ensure that the hole is completely filled. With a Cintec anchor the diameter of the drill hole is normally between two and three times the nominal size of the structural section (and could be still greater) giving a much larger bond area. This is particularly beneficial in weak materials where the low bond stresses combined with the bonding agent maximise the anchorage into the parent material.

With this flexibility it is possible to use the Cintec system for lengths in excess of five metres, several times the limiting length for some similar systems. The length capability is also a result of using structural hollow sections which can double as the grout tube. This guarantees grout injection at the bottom of the hole without grout tubes and gives confidence that the sleeve is effectively filled. Since the anchors are bonded throughout their length it is quite feasible to stop them behind the exposed face and make good the drill hole with coloured mortar or a slip taken from one of the cores.

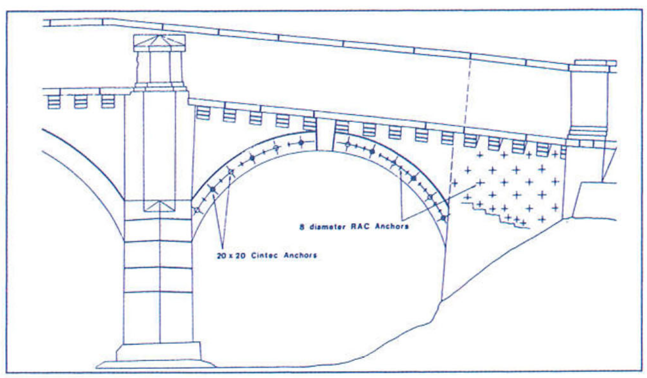
The solution

To prevent any further spreading of the arches it was proposed to tie across the full width of the bridge. The main anchors are 20 x 20 x 2.0 SHS with the lengths, of 2.0m and 1.0m, staggered from both sides of the bridge. This ensures that the lateral stresses are not transferred to a single plane nearer the centre-line of the bridge causing new cracking at this point. Strengthening of the local edge damage to the brickwork of the arches is achieved with the installation of 450mm long RAC anchors formed with 8 x 1.5mm circular hollow sections. The interspacing of the two anchors allowed the 15mm diameter holes for the small anchors to be used for the fixing of the stand used with the diamond drilling of the 52mm holes for the main anchors, this keeping the making good to a minimum. Following grouting of the anchors the holes were made good with coloured mortar to match the brickwork.

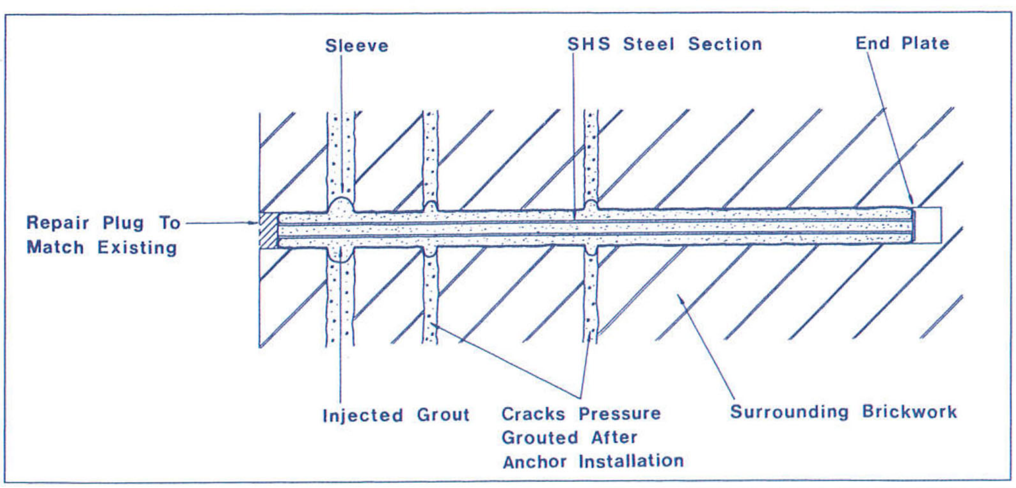
The smaller anchors were also used for repair of the southern wing walls where core drilling of bulged portions of the wall showed that a half brick facing skin was delaminating from the full 600mm thickness of the wall. The high bond capacity meant that an effective anchorage into a single half-brick skin could be achieved while still having the end of the anchor recessed into the face. Once this skin had been tied back the cavity was grouted to stabilise the bulged area.

To complete all the repair work the cracks were surface sealed and grouted with resinous or cementitious grout depending on their width. Brickwork was re-pointed and repaired where this was essential, but this was kept to a minimum because of the difficulty of matching the existing finishes.

The Client, who was responsible for the overall design and for construction supervision, awarded the six-week contract to a Cintec International accredited installer, Brighton based, WT Fixings for a sum of £15,000. Design of sizing and location of the anchors for Cintec International was by the Basildon office of Scott Wilson Kirkpatrick.



Part elevation of the bridge and abutment showing anchor locations



Section through a typical Cintec anchor installation

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- In the UK there are some 40,000 masonry arch bridges in daily use on highways, railways and canals are over 100 years old; some are 500 years old.

- From 1 January 1999, the European Commission Directive 96/58/EEC requires all trunk road bridges to be capable of carrying vehicles of 40 tonnes.

With these facts in mind, Cintec International Ltd, designers of the CINTEC Anchoring System, joined with Gifford and partners, the eminent Civil Engineers, and Rockfield Software Limited, to develop and test the ARCHTEC strengthening technique at TRL.

The ARCHTEC Scheme gives the customer;

- A complete diagnostic, design and installation service utilising state-of-the-art technology and drilling methods.
- Strengthening parameters verified by testing at TRL.
- A product Guarantee and normal Professional Indemnity.

The advantages of the ARCHTEC Scheme are:

- Proven performance under test conditions at TRL
- Easy to install
- Minimum disruption to users
- Minimum disruption to services
- Cost-effective (a fraction of the cost of a saddle)
- Invisible repair and strengthening method

The days of long periods of bridge closure or restricted flow during repair or strengthening are over, with great savings in cost and convenience.

The conclusion of the TRL test, after a load failure point was raised to 41 tonnes. The picture clearly shows the exposed anchors retaining load-bearing capacity.

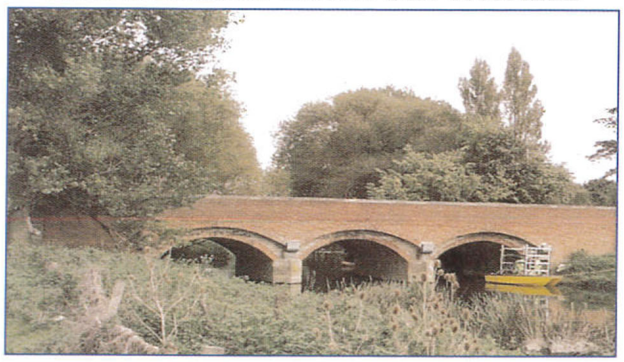
CINTEC Anchors Tried & Tested

ARCHTEC

EXAMPLES OF COMPLETED PROJECTS.

CLIFTON BRIDGE - SCOTTISH BORDERS

MIDDLE BRIDGE - NEWPORT PAGNELL

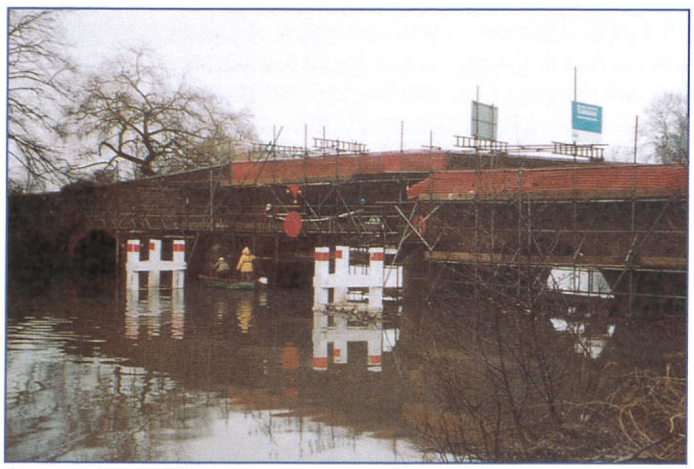


AMBERSHAM BRIDGE - WEST SUSSEX

DUCIE BRIDGE - MANCHESTER

Bridge Contracts

Royal Border Bridge, carrying London - Edinburgh mainline train. Photo : Mel Holley©



Historic Sonning Bridge at Reading

British Rail Bridge Stow-on-the-Wold

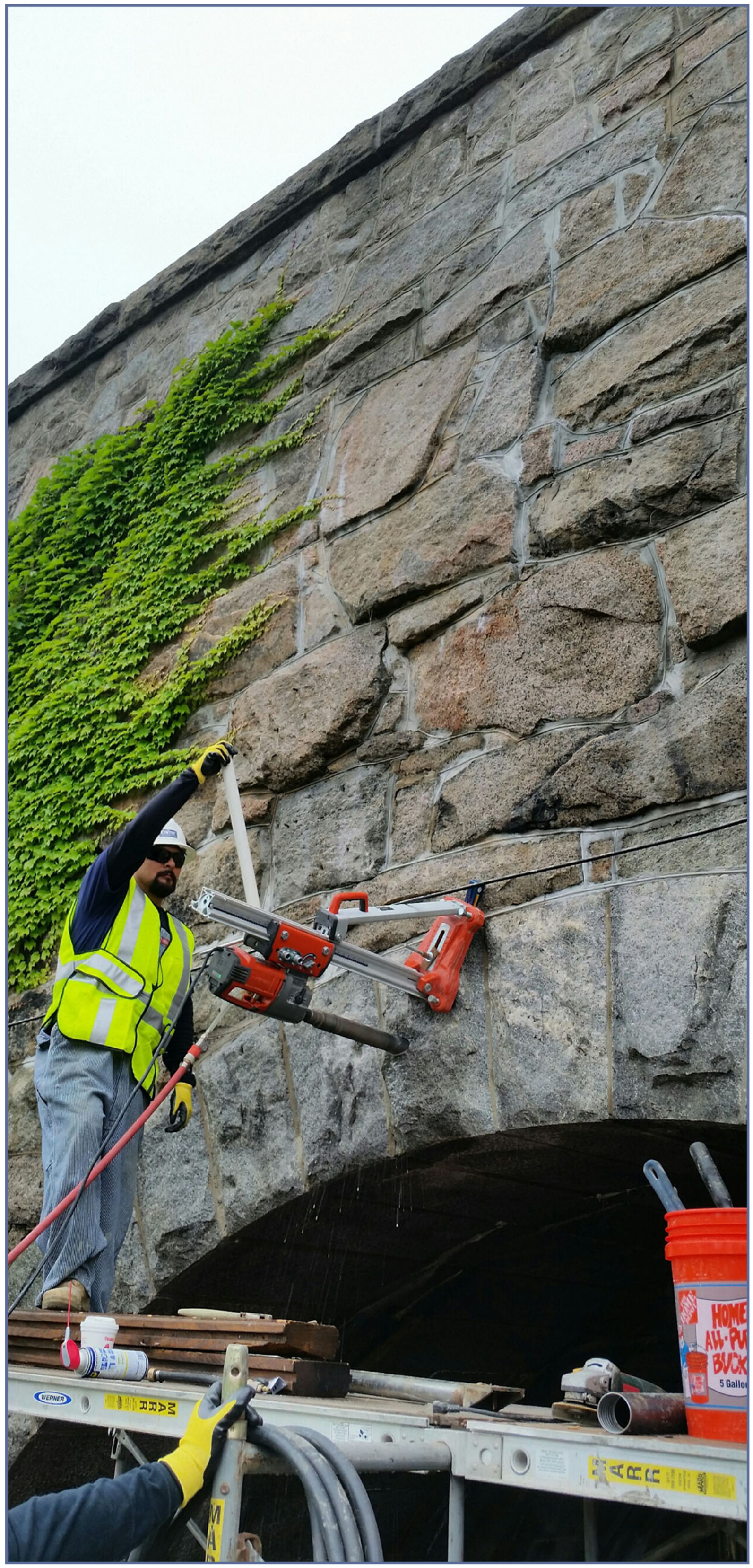
Slattersville Bridge, North Smithfield, RI

Bridge Contracts

Ames St. Bridge, Dedham, MA

Century Lane Bridge, Buck's County, PA

Harrisville Bridge, Harrisville, NH



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