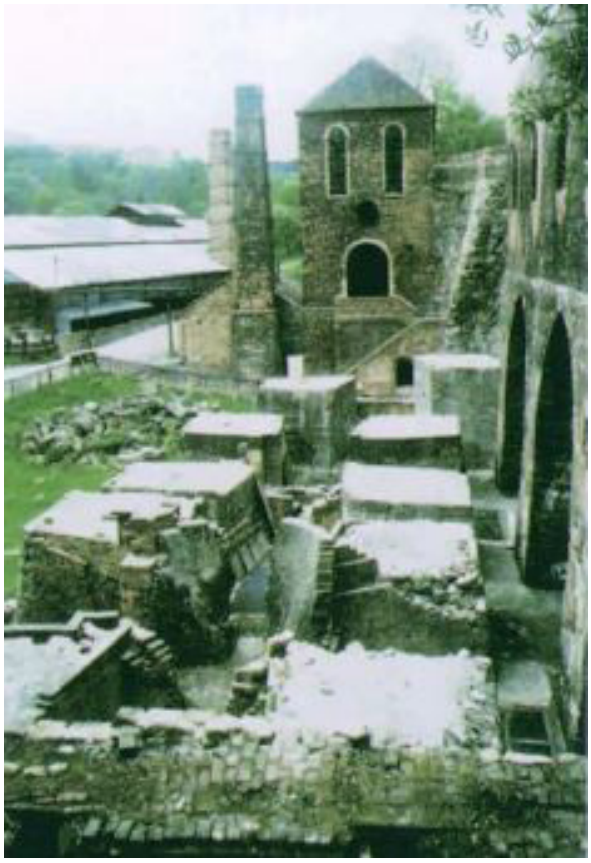
The Restoration and Stabilization of the Blists Hill Furnaces, Telford, England, U.K.



Introduction

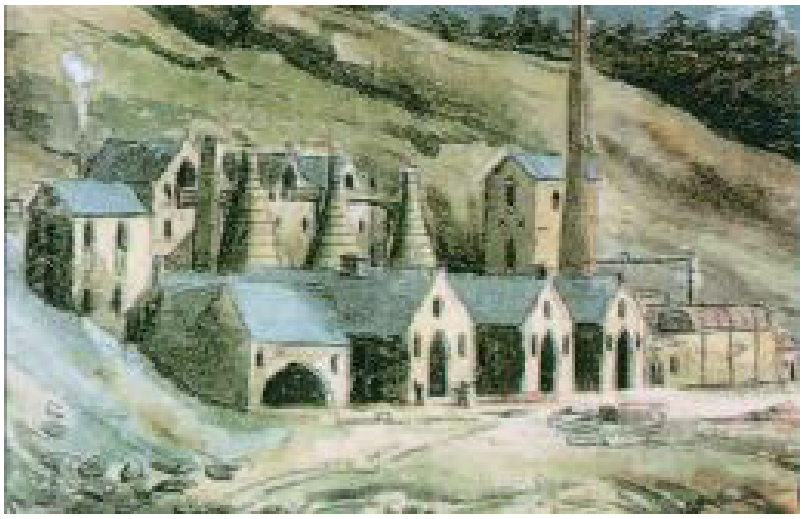
The repair and restoration of the Blists Hill Furnaces, which form part of the Blists Hill Open Air Museum Site near Ironbridge, Telford, has recently been completed. The works were instigated as part of a major repairs programme designed to renovate and restore, numerous structures within the Ironbridge Gorge heritage Site.

A detailed repair schedule was prepared for each of the sites by a working party, including architects, civil and structural engineers, surveyors and archaeologists and the work funded by the Department of the Environment. The purpose of the repair work was to restore and renovate the properties and structures to an acceptable condition whereby the ownership and future maintenance of the structures would pass into the care of Ironbridge (Telford) Heritage Foundation.

In order to bring about the restoration and stablisation of the Blists Hill Furnaces, it was necessary to undertake remedial work on the existing brickwork and stonework, together with the introduction of extensive ground anchors and tie bars.

Work required to prevent further ingress of surface ground water into the furnaces was undertaken as a separate, but integral, phase of the works.

Background History



The Madeley Wood Company was formed in 1756 when the ironworks at Bedlam, one mile west of Blists Hill, on the river Severn, was founded. The Bedlam Furnaces were owned by this company, which held mineral leases in Madeley Parish, enabling it to extract coal and iron ore. Upon its opening in 1790, the company had access to the Shropshire Canal, the Blists Hill section of which ran immediately to the east of the Blists Hill works site. Proximity of raw materials and the means of transporting the finished product persuaded the company to build a blast furnace at Blists Hill in 1832.

Additional furnaces were added in 1840 and 1844, making a total of three and the site remained active in the production of pig iron until 1912, when the ironworks ceased production, following the blowing in of two of the furnaces.

The site history through the 20th century is less well documented. Dense vegetation was allowed to establish itself amongst the ruins until the late 1950's when the site was subject to spoil dumping which completely buried the furnace bases. In the 1970s the Ironbridge Gorge Museum Trust began clearing and restoring the works.

Structural Defects

The buildings had fallen into poor repair due to the ravages of time and the ingress of ground water. This dereliction and general instability of the furnace structures represented a hazard to the preparation of a specification for the repair. It was, therefore, necessary to undertake the design and installation of an extensive scaffold propping scheme to enable the façade of the structure to be stabilized sufficiently to enable the appraisal and detailing of repair work.

The scale of works was restricted due to the nature, historical and archaeological importance of the site. Problems were encountered during the design stage of the scheme due to the presents of many underground tunnels and chambers which linked the surface bases back to the main engine houses.

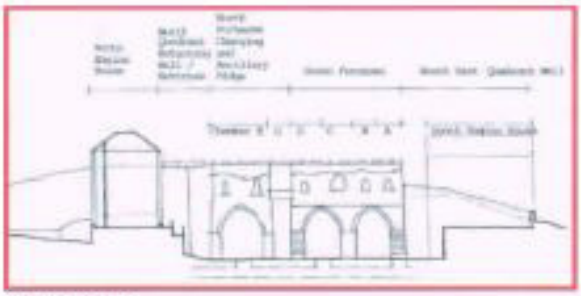
By buttressing the supporting scaffolding back into the old furnace bases and utilizing heavy concrete blocks as kentledge, sufficient dead weight was applied to stabilize the temporary propping. Prior strengthening of the furnace bases was required to ensure that the high loads from the buttresses could be transferred to the sub-strata without distressing the superstructure.

Drilling

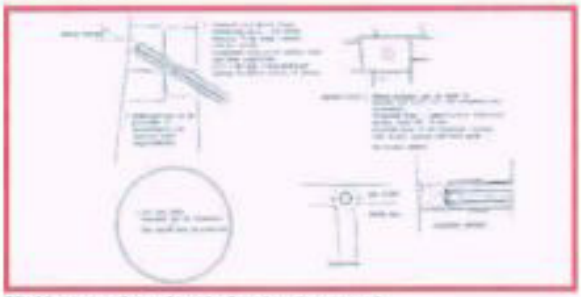
Restoration work in progress

Following completion of the propping scheme a detailed visual and photographic inspection of the site structures was undertaken to ascertain and record the condition of the walls and to determine the cause of the damage, enabling the formulation of a repair and stablisation strategy. This appraisal concluded that the damage which has occurred could be generally summarized as follows:

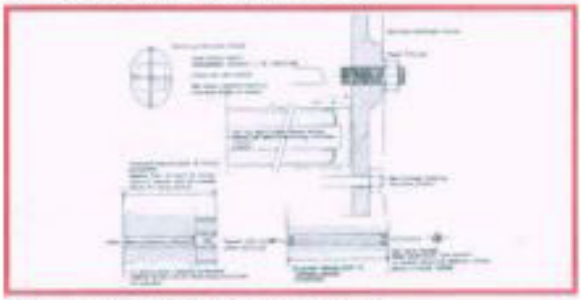
- Superficial damage of the masonry and stone walls cause by the presence of vegetation and water ingress. This was most evident at the top of the structure, where significant loosening of the brick and stonework had occurred with subsequent loss of the retained material. Water penetration, in conjunction with frost action, was also causing significant deterioration to the fabric of the brickwork and stonework.
- Differential settlement in the south wall of the furnace charging building resulting in westward rotation of part of the wall and consequent vertical and diagonal cracking through the superstructure supported by it.
- Cracking and spreading movements in the superstructure, resulting in outward displacement of walls.
- Distress cracking, loss of material and localized collapse of the stone masonry retaining walls which were up to 13m high.



Side Elevation



Making good anchor holes in stonework



Making good anchor holes in stonework

Completed renovation

The geology of the retained ground was investigated, using shell and auger holes, with subsequent laboratory tests to determine the characteristics of the subsoil's. The investigation concluded that the site is ovwelain with topsoil on fill materials form 6 – 11m deep. The fill is principally ash containing one or more of brick and tile discards, blast furnace slag and coal. It is deposited on mudstones containing strata or lenses of standstone and hard clay. The mudstone at the fill interface id frequently softened to a medium clay due to weathering caused by the presence of ground water.

Rates of deformation and crack development

Since the excavation of the structure in 1980, a number of structural movements appear to have taken place, as evidenced by cracking and distortion of early repairs undertaken by the Ironbridge Gorge Museum Trust. No long term records exist, but during the preparation of reports for the repairs brief, it was visibly noticeable that movement and cracking was worsening, confirming that it was progressive. In addition to this cracking, rusting of the cast and wrought iron plates, lintels and tie bars within the structure was continuing, due to the ingress of ground water, with a consequent splitting and heaving of masonry. This in turn caused increase water penetration to the structure.

Remedial Measures

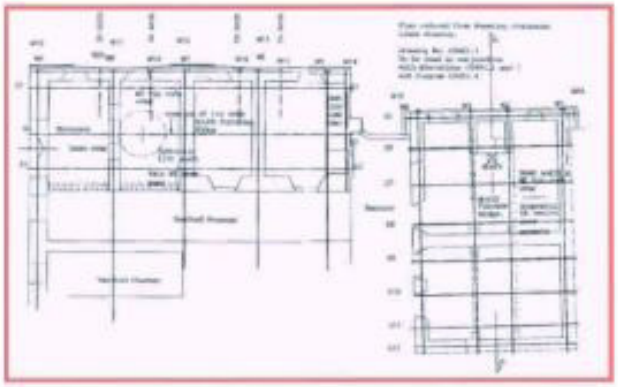
Following detailed discussions with English Heritage, a series of remedial measures to stablise the structures was proposed. This work included the general consolidation of voided and eroded brickwork and stonework in conjunction with the installation of new tie bars and ground anchors. The selection of the ground anchor and tie bars was the subject of careful consideration, due to the very significant archeological and historical importance of the structure.

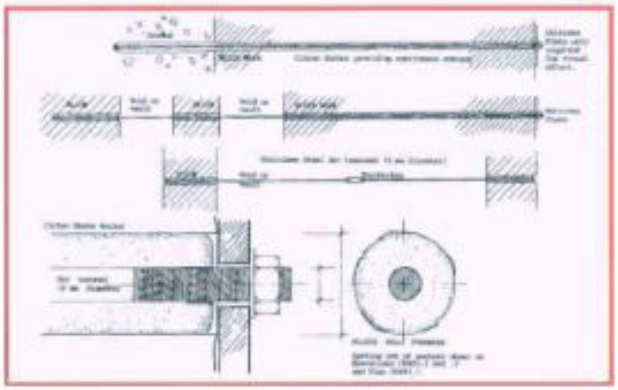
Concern was expressed that any grout used in the anchoring works should not be allowed to penetrate areas of the structure in an uncontrolled fashion.

The Cintec Anchors provided not only the correct structural solution to the problems but also enabled the work to be undertaken in a controlled manner, with the grout restricted to only those areas around the anchors where it was structurally required. The Cintec Anchors were used to replace the eroded and rusted tie bars, in addition to their use for the ground anchorage work on the project.

Careful consideration and planning was undertaken by the design team in conjunction with the specialist sub contractor so that all the anchors and ties were installed with minimal visual disturbance to the building structure, not only during installation but also upon completion of the work. The ground anchors were required to sustain a maximum safe working load of 60kN and this was achieved by socketing the Cintec Anchors a minimum of 3.0 m into the mudstone strata.

The ground anchor installation required a 100mm diameter core to be taken out of the center of a selected stone within the retaining wall. Drilling was then undertaken with or without a steel casing, using an air flush drilling system, to a designed anchor position and length of embedment into the underlying mudstone. Even with this angular adjustment the length of the Cintec Anchors was in excess of 20m. The Cintec Anchor was then inserted in the hole with the sock positioned around the anchor. The whole anchor was then pressure grouted to within 100mm of the face of the wall. Finally the original core was refitted into the core hole and resigned into position so as to mask the end of the anchor.





Where necessary, due to the location of the anchor within the wall and the adjacent stones, the insertion of small diameter stainless steel needles was undertaken. This ‘stitching’ the area around the anchor together. Generally a Cintec RAC 10 mm diameter anchor was employed with the anchors positioned into the bed joints of the stone retaining wall. In most cases 5 Cintec RAC anchors were installed around each ground anchor position.

Within the south and north furnaces where vault tie bars were to be replaced, the use of the Cintec Anchors was once again adopted. The new ties were inserted adjacent to the location of the existing pattress plates initially removed to enable drilling to take place. The anchors were installed in 50 mm diameter holes cored through the brickwork and where necessary into the mudstone strata behind the structure. The anchors and socks were inserted and grouted within the brickwork/mudstone, leaving the exposed areas of tie bar clear of any grout. The existing pattress plates were re-fixed in their existing position so as to mask the repair works and leave the structural appearance of the building apparently unaltered.

Conclusion

The use of the Cintec sleeved anchors has enabled the stablisation and renovation of this very important archeological and historical structure to be achieved. The anchors were able to satisfy the necessary structural criteria whilst enabling all the operations to be fully controlled, thus producing only a nominal visual and archeological impact on the structure which remained apparently unaltered.