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Did Roman engineering influence the development of 18th century engineering in Northern England and to what extent can it be seen in the archaeology of the region?

The aim of my dissertation is to consider the standard of engineering practised in the Roman period and compare it with that practised in the 18th century. Also, as the title suggests, did Roman engineering influence the development of engineering at the beginning of the "Industrial Revolution" in Britain, particularly to measure its affect in Northern England? The general subject area of the dissertation is to research purpose made structures of the Roman period and to compare the technology and material knowledge of the day with that of a similar structure in the early industrial period. The plan is to consider sufficient structures and engineering methods which, in the first case support a standing army and in the second case, a rising industrial population. Structures and structural techniques were chosen as the subject matter rather than any other engineered artefacts because a structure is part of the landscape and part of the archaeology of the region.

There are many factors that will have had some impact on engineering practises and innovation within the two periods. One particular hypothesis is that the climate, environment and geographic position were important factors in the technological development of Northern England during the Roman and early industrial periods. How did engineers of both periods harness the natural forces and materials available in the region? Were there signs of any local innovation? Was there evidence of technology from abroad and if so how did it transfer to the region?

A major objective of this dissertation is to expose Roman engineered archaeology through the experience of the writer who is a recently retired practising engineer. Any practical solutions from the Roman period are to be compared to similar applications that arise in the early industrial period of the 18th century.

As an engineer, the author spent more than four decades solving technical problems connected with the design and development of products. The key to the success and durability of these products often depended on how well the individual components were joined together or how well they were fixed to their parent structure. Fasteners such as nuts and bolts would appear to be the obvious answer in these modern times, but this method is not always a suitable solution. For instance, the solution may require quick-release devices to rapidly dismantle components because of the large number of the products involved and the time taken to do the work. In preference the quick-release device would be purchased but more than likely it would have to be designed and manufactured to fulfil the exact function. The author became an archaeology student in 1996 and within a few weeks of the start of the course it was noticed in several texts on Roman technology illustrations of quick-release temporary fastener called a Lewis or Lewis Bolt. This ancient device or an adaptation of it could have provided an ideal solution to many of the author's past joining and fastening problems. The Lewis is a masonry stone lifting device, which in combination with a wooden crane, has been in existence for 2500 years. No ancient Lewis, made entirely from iron, has survived the passage of time however, but it's tell-tale receptacle which is a Lewis hole carved into heavy cut stone has survived.

The appearance and mode of operation of the Lewis is best understood with the assistance of the illustration. The Lewis is in three parts and consists of two wrought iron dovetail shaped parts and one plain wrought iron spacer. The two dovetail parts were placed back to back in the diverging slot, previously chiselled out from the centre of the stone block. The spacer located between the two dovetailed parts results in filling the cavity of the Lewis hole. A pin, assembled through a hole pierced through the top of the complete combination fixes the shackle to the Lewis. The assembly is attached to hook, rope and crane. This enables the crane to manipulate the stone in to position. The essential issue is the Lewis tightening in the cavity. The stone coming to rest releases the tension in the rope and the Lewis slackens in the taper of the hole allowing the assembly to be dismantled and the procedure repeated on the next stone block.

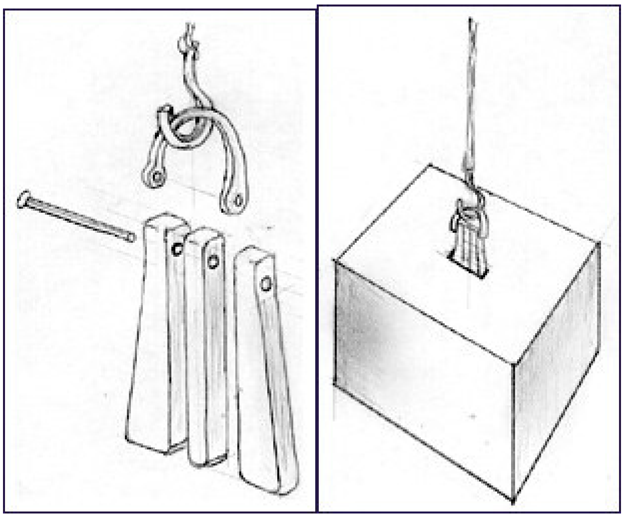
The technique of lifting and locating large cut stone by the use of a Lewis and a Crane is much in evidence on the remains of Roman structures all over the region. Lewis holes, cut 1800 years previously, cover the remains of Roman bridges that crossed many northern rivers. Lewis holes are very apparent on the heavy stonework of the piers and abutment wing walls of the well-conserved bridge site at Chester's on the River North Tyne. The author examined a group of five of these sandstone blocks in-situ located on the wing-walls of the east abutment of the bridge. The internal dimensions of a typical Lewis Hole were determined from one of these five samples along with the size of the five stone blocks. From the dimensions and density of the blocks, their weights were calculated. This dimensional analysis of Lewis holes enabled a typical Lewis to be drawn with a view to producing a wooden model when convenient. Some time later, the author discovered a series of Lewis holes in stonework, which is part of the remains of an 18th century harbour at Seaton Sluice in Southeast Northumberland. The harbour was built around 1750 by the local entrepreneurial family, the Delavals, to enable them to export glassware and coal from the area. There was one Lewis Hole conveniently placed allowing easy access for measurement. This seemed at first just an interesting comparison however; this chance discovery was to trigger off a remarkable chain of events.

The internal dimensions of the Lewis Holes from the site at Chester's Bridge and Seaton Sluice were so alike as to allow a Lewis to fit the Lewis hole at Seaton Sluice. These Lewis holes were chiselled out from stone blocks by masons with the same skills but separated in time by some 1500 years! Equipped with this information the writer then designed, drew and provided materials for a wooden replica of a Lewis to be made by the University's technicians. The dimensions measured at Chester's were used as guidelines to create a model, complete with a sectioned mock stone to demonstrate the Lewis in action. The length of the Lewis hole can vary as much as one centimetre and still work satisfactorily. This made the mason's task easier because of the relaxation in accuracy and it is possible to demonstrate this on the working model. The Lewis provided the inspiration to consider and compare masonry construction techniques in the Roman period and the 18th century and in fact, this extraordinary fastener provided the inspiration for the whole project and the dissertation.
It is safe to say that the Lewis was fully developed in the Roman period and capable, when used with a suitable crane of lifting stone blocks of several tonne in weight. It is virtually the same today being used as a mason's tool as it was in the Roman period,

apart from a few additional safety features. The Lewis is an integral part of British Standard 5390-1976-Lifting Appliances.

From the example of the Lewis, the main objective emerged which was to investigate and compare the essential part of the infrastructure that reflected the most innovative technology, engineering practice and structural techniques. Two topics emerged that seemed to be an essential part of the infrastructure for both periods. These two topics together are essentially hydraulic engineering, although the first topic is bridge construction and river management, and mainly concerned with engineering 'static's', while the second utilisation of waterpower is 'dynamics'.

Another interesting construction technique has emerged from the Roman bridges at Chester's and Corbridge. Several large stone blocks located at vulnerable points on the bridges were secured together with lead tie bars. Molten lead or lead alloy was poured into previously prepared grooves on the top surface running from block to block. The hypotheses is that the lead, two samples from Corbridge and two from Chester's is in fact lead-tin, which would result in reducing the melting temperature and secondly gain in stiffness. To verify this, the 'Excavation and Fieldwork Committee' gave a £100 grant towards the cost of electron-microscopic analysis of the four samples.



Above: The Lewis