

AN EARLY EXAMPLE OF THE USE OF UNDEREXCAVATION TO STABILISE THE TOWER OF ST CHAD, WYBUNBURY IN 1832



GLYNIS JOHNSTON¹, JOHN BURLAND²

¹Private Consultant, ²Imperial College, London

SUMMARY

The technique of underexcavation has been extensively used in Mexico City and elsewhere as a means of conservation and protection of historic buildings and it is being used to stabilise the Tower of Pisa. One of the earliest known examples of the use of the method was by James Trubshaw on the tower of St Chad, Wybunbury, in 1832. The technique pioneered by Trubshaw provides an ultra soft method of stabilising historic buildings experiencing subsidence. The method is completely consistent with the requirements of architectural conservation and as such it offers an alternative to some modern methods of underpinning.

INTRODUCTION

St Chad's tower is situated on a ridge overlooking the village of Wybunbury, five miles south of Crewe and three and a half miles east of Nantwich in South Cheshire (Fig. 1). Historically, it is a church site believed to date back to 669AD when the Mercian Bishop of St Chad established his "See" at Lichfield. There have been many churches on this site, but due to the unstable ground in the area each has had to be demolished. Church warden's accounts reveal that over the years five churches have become unsafe and have had to be demolished in 1595, 1793, 1833, 1892 and 1977. The fifteenth century tower is all that now remains.

The tower, 29.3m tall, 9.8m square and estimated to weigh 1,500 tons, was part of a late fifteenth century church, built in the Perpendicular style. The tower's tendency to lean has earned it the title of the "Leaning Tower of South Cheshire", or in earlier days, the "Hanging Steeple of Wimberie" (Fig 2). Over the past five centuries it has tilted steadily towards the north-east at the rate of between 5 and 10 mm per year.



Figure 1 : Location plan

Wybunbury

Figure 2 : Hanging Steeple of Wybunbury (1751)

THE CAUSE OF THE CONTINUING TILT

The town of Nantwich was once the centre of the Cheshire salt industry and produced salt at least from Roman times until 1856 when it was supplanted by the rival centres of Northwich and Winsford. Brine springs have been recorded in the Weaver Valley over the seven miles from Audlem to Nantwich. The River Weaver runs within two miles of Wybunbury on the South West side. A nearby deep borehole confirms the presence of thick saliferous beds at considerable depth containing in the order of 80% salt.

In 1971 a site investigation was carried out which included the sinking of three boreholes around the church under the direction of Thomas Bedford and Partners, Civil Engineers. The investigation showed that St Chad's is built on no ordinary site. The tower is founded on stiff clay between 1.5m and 4.9m thick, overlying fine sand. The top of the first saliferous beds were estimated to be at a depth of about 107m. It was concluded from the investigations that the whole area on which the tower is founded has been experiencing ground movements due to the combination of deep-seated subsidence, resulting from salt extraction and sand or silt erosion, and shallow-seated creep of the adjacent hillside.

THE WORK OF JAMES TRUBSHAW

James Trubshaw (1777 – 1853) was the son of a builder and engineering contractor and after his

father's death James took over the family business. Although he designed several buildings Trubshaw regarded himself primarily as a builder and civil engineer, and as far as possible avoided any work which he considered to be "interfering with the professional Architect." As a civil engineer his most celebrated achievement was the construction of the Grosvenor Bridge at Chester to the design of Thomas Harrison. This consisted of a single arch of 200ft span – the largest in Britain at the time. Competent engineers, Telford included, were doubtful whether it could be built. The bridge was successfully completed in 1833 and models of the bridge, showing the method of construction employed, were afterwards presented by Trubshaw to the Institution of Civil Engineers (of which he became a member in 1827).

Trubshaw's success as a practical engineer was remarkable in view of his very limited education. He seemed to be gifted with an instinctive perception of mechanical principles, and a combination of intelligence, integrity and hard work enabled him to surmount problems that to others seemed insuperable. It was these very qualities that enabled him to stabilise St Chad's tower.

JAMES TRUBSHAW'S STABILISATION OF ST. CHAD'S TOWER

In 1758, the Wybunbury tower was recorded as leaning north-east by 0.9m and in 1790 this had increased to 1.05m. Just over 40 years later when Trubshaw started his restoration, the tower was leaning over 1.56m from the perpendicular and was split several centimetres along the centre of the building. In the Drawings Collection of the RIBA (among Trubshaw's papers) is a plan of Wybunbury tower (Fig 3) on which is marked the point to which the plumb line was suspended from a height of 26m from the beams under the leads of the tower, to this point. Trubshaw undertook the task of stabilising the tower after others had declined it - in fact the fulfilment of a boyhood wish. His daughter recorded that even as a boy her father had conceived the method by which the tower should be stabilised.

The following extract [1] in the Architectural Magazine of 1836 describes the method he used :-

"Mr Trubshaw, after examining well the outside of the foundations, commenced digging down the inside. After having got below the level of the footings (lowest stones of the foundation), he proceeded to bore a row of auger-holes clear through under the foundations of the high side, the holes nearly touching each other. These holes he filled with water; and, corking them up with a piece of marl, let them rest for the night. In the morning, the water had softened the marl to a puddle; and the building gradually began to sink, another row of holes were bored, but, not exactly so far as the first row. They were filled with water as before; and the high side not only kept sinking, but the fracture in the centre kept gradually closing up. This process was continued till the steeple became perfectly straight, and the fracture imperceptible."

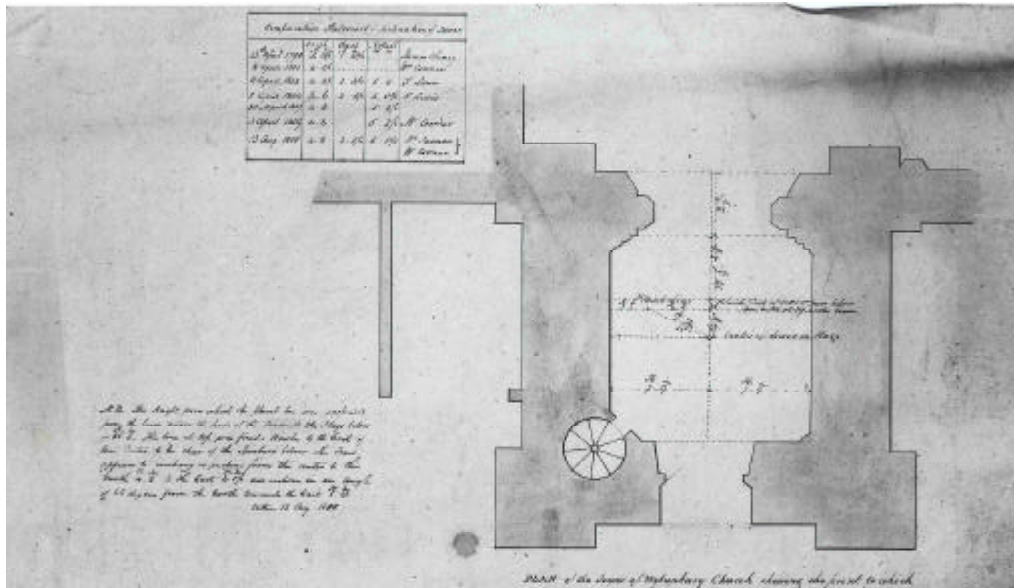


Figure 3 : Trubshaw's Plan (by permission of the RIBA Library Drawings Collection)

Trubshaw drilled the extraction auger holes just below the foundation of the tower which is known to extend to a depth of 1.73m. The borehole alongside the tower reveals that the soil at this depth is stiff red-brown boulder clay with occasional sand lenses. Trubshaw stabilised the tower without any "wonderful machinery or secret inventions"[2]. Using this procedure the building suffered the minimum intervention which by today's standards would be considered to be a good restoration.

It is interesting to note that in 1962 Terracina[3] proposed a method whereby inclined drill holes are used to extract soil from beneath the high side of the foundations of the Leaning Tower of Pisa. This proposal attracted little attention until the Mexicans developed the method for straightening buildings which had experienced differential settlement. They coined the term "underexcavation" and have successfully employed the method to stabilise the Metropolitan Cathedral of Mexico City[4]. The method is now being used to stabilise the Leaning Tower of Pisa[5].

Although the tower of St Chad had been successfully stabilised it was apparent that the body of the church generally was in such a dilapidated state that an agreement was made with James Trubshaw to rebuild it. The old church was demolished in 1833 and Trubshaw built the new church, retaining the fifteenth century tower, ten yards away from the position of the previous one. Such was the instability of the soil that by 1891 Trubshaw's church had also become structurally unstable and was demolished in 1892.

CONTINUING CONCERN FOR WYBUNBURY CHURCH

In 1891 Professor DeRance, a distinguished geologist, wrote a report to the Wybunbury Church Restoration Committee. He drew attention to the deep-seated nature of the instability of the ground extending laterally to the west of the site by many hundreds of metres. This was evident from damage to nearby buildings, walls, roads and the churchyard. In referring to the founding of a new church he stated that:

.....“to have any chance of rendering the foundation of a new structure secure, it would be necessary to go down somewhat below that level, say 50 feet, to obtain any probability of safety.”

He went on to point out that this would be extremely expensive and fraught with great danger to the churchyard. Having considered carefully “all expedients that might be used to save the site” he suggested that the Committee find another safer site for the Church.

The Committee chose to ignore his advice and in 1892 the foundation stone of the last church was laid. A third of the building cost was spent on the foundations and it was hoped that these would overcome the problems. However less than eighty years later in 1973, Raymond Richards, in his book "Old Cheshire Churches", described how the church had rapidly deteriorated and that although some attempts to support it had been made there was concern for the structure "with no obvious solution". The last church was demolished in 1977.

This brief history of the churches at this site is a clear confirmation of the instability of the underlying ground making Trubshaw's intervention on the tower even more remarkable.

THE SECOND STABILISATION OF ST CHAD'S TOWER

Efforts now concentrated on saving the tower, which was again tilting significantly towards the north-east. In January 1971 it was estimated that the tower was about 1.04m out of plumb. Over the period January 1971 to January 1982 the tower moved a further 152mm. It was clear that the tower was continuing to incline at a rate of about 13 mm a year and that this movement was likely to continue indefinitely. In addition to the changing inclination a similar picture emerges for the settlement of the tower. The levels of an Ordnance Survey benchmark on the west wall of the tower provide direct evidence of the considerable subsidence taking place at the site. Between 1882 and 1960 (when the benchmark was abandoned) the tower settled at least 300mm.

Following an inspection in 1982 it was concluded that the foundations of the tower were spreading and that the SW corner near ground level had deteriorated seriously since 1971. External cracks near ground level on the north face had also extended. However at the ringing chamber level and above there was little or no sign of cracking or deterioration of stonework. To prevent further movement and distress to the masonry it was decided that the tower should be underpinned by “an extremely stiff foundation”

In the event, St Chad's tower was underpinned in 1989 by constructing a reinforced concrete slab beneath the existing foundations which were themselves strengthened. Jacks were then inserted between the concrete slab and the foundations and the inclination of the tower was reduced from 1.19m to 0.46m. Like the Pisans, the inhabitants of Wybunbury were concerned that their tower should be stabilised but not lose its characteristic lean. A controversial aspect of the underpinning operation was the removal of the inverted arch built by Trubshaw in 1832 to help stabilise the foundations, thereby removing an interesting and important part of the

history of the tower. This action was arguably a contravention of Article 7 of the Venice Charter of 1964 which reads:

“A monument is inseparable from the history to which it bears witness and from the setting in which it occurs. The moving of all or part of a monument cannot be allowed except where the safeguarding of that monument demands it or where it is justified by national or international interests of paramount importance.”

It is possible that Trubshaw's method of reducing the tilt of St Chad's tower could have been adopted as a permanent solution with periodical adjustments. Whatever the method, the need to strengthen the foundations was unavoidable because of the serious cracking of the masonry.

THE RELEVANCE OF TRUBSHAW'S WORK TO THE PISA TOWER

Trubshaw's method uses the minimum intervention that is needful; it is reversible or if necessary, repeatable, and it is also invisible. These principles take into consideration not only the technical, but also the historical and conservational concerns relating to the building. Article 3 of the Burra Charter (1988) states:

“Conservation is based on respect for the existing fabric and should involve the least possible intervention. It should not distort the evidence provided by the fabric.”

It is this principle which renders the application of underexcavation at Pisa so attractive.

Also of importance is the historical precedent provided by Trubshaw's work. Article 10 of the Venice Charter (1964) States:

"Where traditional techniques prove inadequate, the consolidation of a monument can be achieved by the use of any modern technique for conservation and construction, the efficacy of which has been shown by scientific data and proved by experience."

Trubshaw's successful stabilisation of St Chad's Tower provides a valuable early case record of the application of underexcavation to the conservation of an historic building.

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